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BRUCE GS 'B' PREOPERATIONAL BIOLOGICAL STUDY SUMMARY, 1979 TO 1983

Report No 87-185-K

H. Balesic and I.D. Martin
Biological Research Section
Chemical Research Department

ABSTRACT

Preoperational environmental studies for Bruce GS 'B' were carried out from May 1979 to February 1983 over an area extending from Douglas Point to McRae Point. Baseline data were acquired for a wide range of physical, chemical and biological characteristics, with major emphasis on fish populations. Due to the exposed nature of the shoreline, variation in many parameters, including temperature, substrate, sedimentation, transparency, density and composition of benthic flora and fauna and larval fish was evidently strongly influenced by wind induced disturbances and currents. Water chemistry, benthic algal biomass and faunal communities were generally representative of cool, unpolluted oligotrophic waters. The fish community was dominated by forage and coarse species, the most abundant of which were alewife, rainbow smelt, spottail shiner, longnose sucker and white sucker. Round whitefish, which apparently spawned in the vicinity of the site in late November-early December, and yellow perch occurred in moderate numbers. Temporal and spatial distributions of major fish species were generally consistent with previously reported life history characteristics.

job	file	date	report no.
34-142-492	837.321BRU	October 16, 1987	87-185-K

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EXECUTIVE SUMMARY

BRUCE GS 'B' PREOPERATIONAL BIOLOGICAL STUDY SUMMARY, 1979 TO 1983

H. Balesic and I.D. Martin
Biological Research Section
Chemical Research Dept

Preoperational environmental studies for Bruce GS 'B' were carried out from May 1979 to February 1983 at the request of Environmental Studies and Assessments Department, Design and Development Division. Bruce GS 'B' is the most recent addition to the Bruce Nuclear Power Development (BNPD) which also includes the Bruce Heavy Water Plant (BHWP), Douglas Point GS and Bruce GS 'A'. The objective of the Bruce GS 'B' study was to describe the aquatic environment of the site in sufficient depth that comparison with subsequent commissioning and post-operational studies could show the nature and magnitude of environmental alterations attributable to station construction and operation. This will allow verification of the 1975 environmental assessment and an evaluation of the various environmental measures provided for at the Bruce GS 'B' plant.

The environmental study program was extensive in scope in 1979 and 1981, limited in 1980 and supplementary in 1982-83. A wide range of physical and biological characteristics of the aquatic environment were investigated, with the major emphasis placed on fish populations. The study area extended from Douglas Point in the north to McRae Point in the south, a distance of approximately 8 km; two transects, Douglas Point and Gunn Point were also included in Bruce GS 'A' aquatic studies.

The physical characteristics of the site are typical of Great Lakes shorelines exposed to the action of prevailing winds. Substrates are predominately coarse, and sedimentation, water clarity and temperature are all strongly influenced by wind-induced disturbances. Water chemistry is typical of unpolluted, oligotrophic fresh waters.

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Seasonal changes in community composition of phytoplankton, zooplankton and attached algae were similar to those observed at other Great Lakes generating stations with the exception of the persistence of the cold-water attached alga, *Ulothrix* spp., into the summer. Attached algal biomass was quite low, as might be expected from low nutrient status of the waters and frequent disturbance by wave action. The zoobenthic community was dominated by oligochaetes and dipteran larvae, with some segregation by depth and season evident. Substantial temporal variation in zoobenthic densities was attributed to the timing of sampling relative to natural disturbances and the life cycles of the species.

A variety of techniques were utilized to sample larval, juvenile and adult fish with pelagic, benthy-pelagic and demersal habits. Temporal and spatial distributions of the major species were generally compatible with known life-history information. The fish community at the site was dominated by forage species, especially alewife, rainbow smelt and spottail shiner. Other common species included longnose suckers, white suckers and gizzard shad which are considered to be coarse fish. While not of direct value to man in commercial or sport fisheries of northeastern Lake Huron, these species are nevertheless important components of nearshore food webs. Alewife and gizzard shad occur at the site in sufficient numbers at certain times of the year to suggest the potential for future operational problems through massive impingement.

Round whitefish and yellow perch, potentially valuable commercial or sport species, occurred at the site in moderate numbers. Adult round whitefish were present in largest numbers prior to and during their fall reproductive period, spawning in late November-early December in undetermined locations. Young and adult yellow perch utilized the area in late summer and fall, well after their spring reproductive period. Adult walleye and smallmouth bass appeared at the site in relatively small numbers. The abundance of these valued game fish may increase with the addition of the heated discharge of Bruce GS 'B'.

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To Dr. W.R. Effer
Manager, Environmental Studies
and Assessments
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BRUCE GS 'B' PREOPERATIONAL BIOLOGICAL STUDY SUMMARY, 1979 TO 1983

1.0 INTRODUCTION

This report provides a summary and synthesis of preoperational environmental data acquired at the Bruce GS 'B' site of the Bruce Nuclear Power Development (BNPD) from May 1979 to February 1983. The study was requested by the Environmental Studies and Assessments Department, Design and Development Division. The objective of the study was to describe the physical, chemical and biological characteristics of the aquatic environment in sufficient detail that subsequent comparisons to commissioning and post-operational studies would allow for an evaluation of environmental impact resulting from construction and operation of Bruce GS 'B'.

The proposal for Bruce GS 'B', submitted in 1975, included an environmental assessment (aquatic, terrestrial and atmospheric) based on then-current information for BNPD and on the demonstrated effects of other generating facilities. There was construction activity at the Bruce GS 'B' site from 1976 to 1983 and the four units of the station were commissioned between 1983 and 1987. The scope of the preoperational aquatic study program was extensive in 1979 and 1981, limited in 1980 with additional supplementary work conducted in 1982/83. A wide range of physical and biological characteristics of the aquatic environment were examined. Pre-operational terrestrial studies were limited to gulls in 1980. A broader terrestrial program was carried out during the commissioning phase, to be compared with pre-construction information collected for the original environmental assessment. The results of the preoperational studies have been presented in OHRD (Ontario Hydro Research Division) Reports 83-182-K (Yr I), 82-205-K (Yr II), 83-451-K (Yr III), and 83-507-K (Yr IV).

Environmental studies at the Bruce GS 'B' site should not be considered in isolation, but as an integral part of studies at the entire BNPD site, including Douglas Pt GS, Bruce GS 'A' and BHWP (Bruce A and B Heavy Water Plants). Studies at Douglas Pt began as early as 1970 (Fry and Everest 1971) and a large volume of environmental data were collected from Sand Bay to Gunn Pt during Bruce GS 'A' preoperational and commissioning studies (1973 - 1978) and Once-Through-Cooling fish spawning investigations (e.g. OHRD Reports 76-343-K, 80-43-K, 80-45-K). The Bruce GS 'A' postoperational study (1979 to 1981) coincided with the Bruce GS 'B' preoperational study, and included two shared sampling locations (Douglas Pt in the north and Gunn Pt in the south). These studies are summarized in OHRD Report 84-47-K.

2.0 METHODS

2.1 Study Area and Sampling Program

The Bruce GS 'B' aquatic study area extended from Douglas Pt in the north to McRae Pt in the south, a distance of approximately 8 km (Figure 2.1-1). Most sampling was conducted along the shoreline and at the 1, 3, 7 and 12-m depth contours along nine transects: Douglas Pt, Lagoon Bay, Bruce GS 'B' discharge, Bruce GS 'B' intake, South Boundary Point, Holmes Bay, Gunn Pt, Inverhuron Bay and McRae Pt. In 1979 the study area extended only to Gunn Pt. Douglas Pt and Gunn Pt transects were also used in the Bruce GS 'A' aquatic survey. In one case (1981 whitefish spawning study) three transects north of Douglas Pt were added. Two activities extended beyond the 12-m contour: plankton sampling and acoustic fish census were conducted on grids extending approximately 2 km offshore, to about the 35-m depth contour.

Terrestrial work consisted of a gull nesting survey (1980) that was limited to armour stone and landfill areas within the Bruce GS 'B' site.

The sampling activities conducted in each year are summarized in Table 2.1-1.

2.2 Physical and Chemical Characteristics

2.2.1 Substrate

Substrate composition was determined from photographic slides taken by SCUBA divers at depths of approximately 0 (splash zone), 1, 3, 7 and 12 m on seven transects from Douglas Pt to McRae Pt. Additional sampling involved intermediate depths in 1979, and additional (intermediate) transects in 1980-81. All

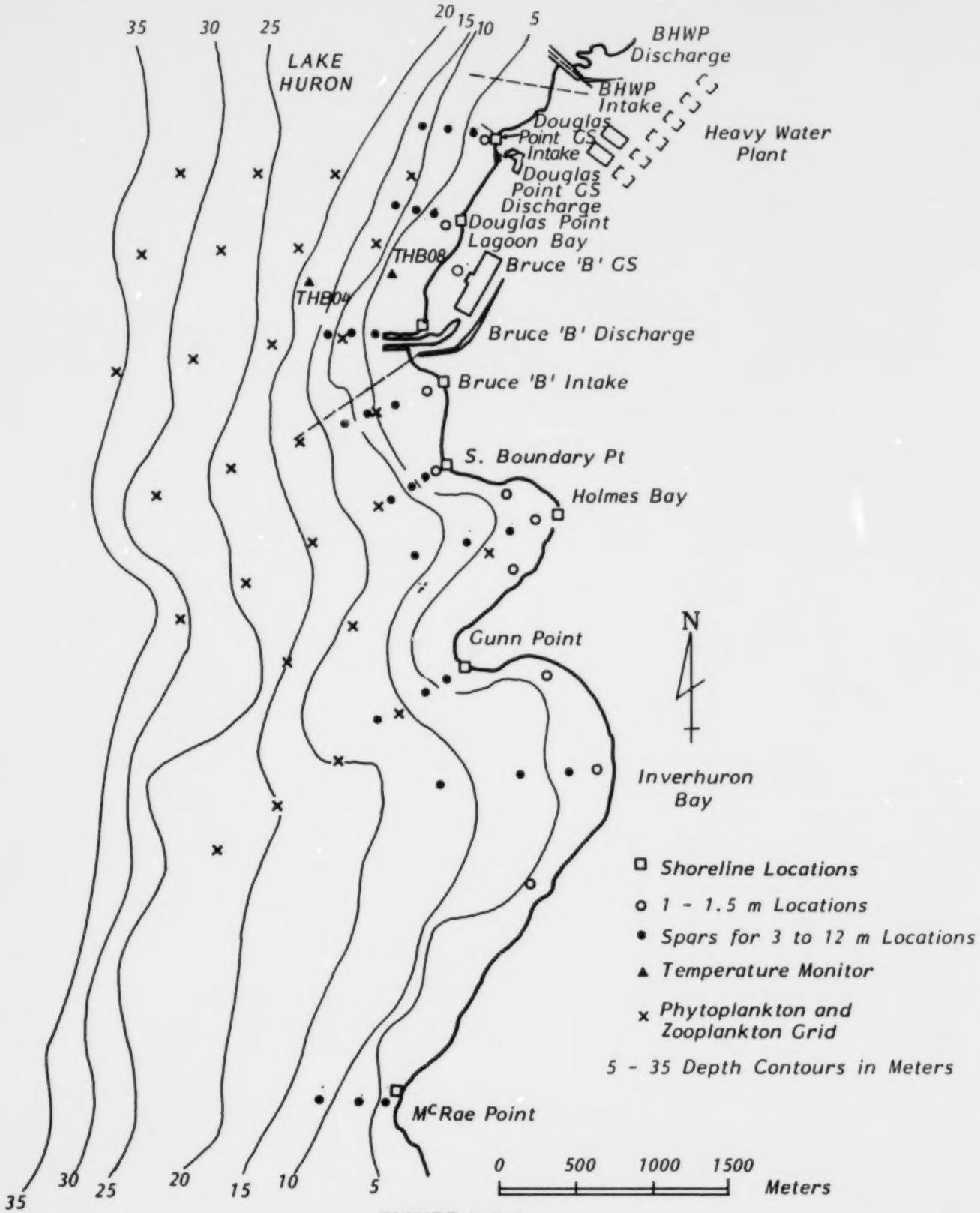


FIGURE 2.1-1

SAMPLING LOCATIONS FOR BRUCE GS 'B'
PREOPERATIONAL STUDY

TABLE 2.1-1

SUMMARY OF BRUCE GS 'B' PREOPERATIONAL SAMPLING PROGRAM

Activity	1979	1980	1981	1982	1983
PHYSICAL, CHEMICAL					
Bottom substrates, extensive	X	X			
supplementary			X	X	
Sedimentation rates	X	X	X		
Continuous temperature monitoring		X	X		
Temperature, Oxygen profiles, transparency	X	X	X		
Water chemistry	X	X	X		
Sediment chemistry	X				
BIOLOGICAL					
Phytoplankton and zooplankton	X				
collection only			X		
Attached algae	X		X		
Zoobenthos	X		X		
Fish:					
May-November gill netting	X	X	X		
Winter gill netting			X		X
May-October trap and seine	X	X	X		
Acoustic fish census	X	X	X		
Larval fish tows, extensive	X		X		
limited		X		X	
Whitefish spawning		X	X		
Feeding	X				
Growth	X	X	X		
Nesting Gulls		X			

locations were sampled by three replicates in 1980-82, while the number of replicates in 1979 ranged from 1 to 3, depending on the heterogeneity of the substrate.

Particle-size analysis using the wet sieve method was carried out on samples collected by divers in 1979. These collections were limited to locations that consisted of small substrates less than 40 mm diameter.

2.2.2 Sedimentation and Sediment Chemistry

Sediment traps consisting of four upright tubes with 5 cm inside diameter were set for two periods in 1979 (May - August, September - November) and for three periods in 1980 and 1981 (May - July, July - September, September - November). Nine transects were sampled at the 3, 7, and 12-m depths in the latter two years, while only the northernmost seven transects were monitored in 1979 (Figure 2.1-1). Collected sediment samples were dried to constant weight at 125°C, then ashed at 550°C to determine weight loss-on-ignition (and per cent loss) which provides an estimate of sediment organic content. The weight of the sample following ignition is a measure of sediment inorganic content.

Variances and means of all sedimentation variables (inorganic and organic sedimentation rates, per cent organic matter) were highly, and significantly, correlated. To meet the assumptions of analysis of variance (ANOVA), appropriate transformations of these variables were calculated by application of Taylor's Power Law (Taylor 1980). Logarithmic (inorganic and organic sedimentation rates) and arc-sine square-root transformations (per cent organic matter) were performed. Tests of the transformed distributions (skewness, kurtosis, normal probability plots) confirmed that the variances were adequately stabilized for their use in analysis of variance (Sokal and Rohlf 1969).

Chemical analysis of sediment samples for the purpose of quantifying heavy metal concentrations was carried out in 1979. Subsamples of sediment collected in sedimentation tubes (rate studies) were submitted to Analytical Services Section, Chemical Research Department, for analysis of the heavy metals. Sediment sampling proposed for the 12 m depths of the Bruce GS 'B' intake and discharge transects was not carried out; substrate composition at these sites was mainly boulder and cobble, and no areas of sediment deposition were found.

2.2.3 Temperature, Dissolved Oxygen and Transparency

At Hydraulic Studies instrument station THB08, water temperatures at the 2-m depth were monitored at monthly intervals in

1979 and continuously in 1980 and 1981. In addition, temperature and dissolved oxygen profiles were constructed from readings at 1-m depth intervals taken monthly from May - November, 1979, and from June - November, 1981, at the 12-m depth of the Bruce GS 'B' Intake and Gunn Pt locations. Water transparency was also measured at these locations. Additional temperature and transparency data were gathered in conjunction with biological sampling programs (Section 2.3).

2.2.4 Water Chemistry

Water samples for chemical analysis were collected with a Van Dorn sampler in June, August, and October in 1979, and monthly from May to October in 1980 and 1981. In 1979 samples were taken near the surface and bottom at the 12-m depth on the Bruce GS 'B' intake transect and at the surface (3-m spar) on Bruce GS 'B' discharge transect. In the succeeding two years, water samples were collected at these same locations and near the surface at the 7-m Bruce GS 'B' discharge spar. Sampling and analytical effort is detailed in Table 2.2-1. Analysis was performed by the Analytical Services Section, Chemical Research Department.

2.3 Biological Characteristics

2.3.1 Phytoplankton and Zooplankton

Plankton samples were collected from a 28-location grid (Figure 2.1-1) in June, August, and September - October of both 1979 and 1981 using standard collection and preservation techniques (Ontario Hydro Research Division Report 83-182-K). Abundances of both zooplankton taxa (No. m^3) and phytoplankton taxa (mg/m^3) were determined only for the 1979 collections with Mutual Information Analysis procedures being used to identify assemblage composition in these collections. Mutual Information Analysis is a hierarchical classification method which orders samples relative to their similarity in taxonomic composition using the principle of Information Theory (Green 1979). Samples are fused together based on shared information among successive cumulative pairings. The assemblages formed by the analyses were further reduced by combining successive groups with similar species dominance although species abundance may have indicated separate groupings.

At the time of the plankton collections dissolved oxygen and water temperature were measured in near surface waters, as was water transparency (Secchi disc method).

TABLE 2.2-1

SAMPLING AND ANALYTICAL SCOPE OF WATER QUALITY DETERMINATIONS

	1979	1980	1981
Sampling			
June, August, October	X	X	X
May, July, September	-	X	X
Bruce GS 'B' Intake 12 m surface	X	X	X
bottom	X	X	X
Bruce GS 'B' Discharge 3 m surface	X	X	X
7 m surface	-	X	X
Analysis			
pH, color, specific conductance,	X	X	X
Turbidity, Chemical Oxygen Demand	X	X	X
Biological Oxygen Demand	-	X	X
Total Organic Carbon, Sulphate, Aluminum Total & Dissolved Iron, Sodium	X	-	-
Filterable Residues at 105°, 550°C	X	X	X
Non-Filterable Residues at 105°, 550°C	X	X	X
Soluble Phosporus	-	-	X
Total Phosphorus, Ortho Phosphorus	X	-	X
Total Kjeldahl Nitrogen, Soluble Nitrogen	X	-	X
Nitrite Nitrogen, Nitrate Nitrogen, Ammonia	X	-	X
Total Silica, Soluble Silica	X	-	X
Calcium, Magnesium, Chlorophyll a	X	-	X

2.3.2 Attached Algae

Three replicate samples of 0.25 m^2 were scraped from available solid substrate at the 1-m and 3-m spars of seven Bruce GS 'B' transects in June and August of 1979 and 1981, as well as in October (1979) or November (1981) (Figure 2.1-1). Coincident water temperature measurements were made at the substrate level when algal samples were collected. The samples were preserved in 5% formalin and species composition determined in the laboratory. After drying to constant mass at 105°C, samples were ashed at 525°C to determine mass lost upon ignition which was used on an estimate of sample organic content (including seston).

2.3.3 Zoobenthos

In 1979 and 1981, triplicate zoobenthos samples were collected at the 1, 3, 7, and 12-m depths of seven northern transects at the Bruce GS 'B' study site (Figure 2.1-1). Two collections were made in each year, one in early summer (June - July) and one in late fall (October - November).

Samples were collected with a dome (area 0.01075 m^2) and slurp gun operated by SCUBA divers, and preserved in 5% formalin solution. Substrate composition and algal cover were estimated by divers. Other physical variables quantified were dissolved oxygen and temperature (1 m above the substrate), as well as Secchi disc readings. Invertebrates were identified to species where possible. Immature individuals could be identified only to genus, or in some cases to the sub-family level. Mutual information analysis was used to identify the composition and distribution of zoobenthic assemblages.

2.3.4 Fish

Adult and Juvenile Fish

A monthly netting survey employing gill nets, trap nets and beach seines was carried out during the open water period in each year from 1979 to 1981. Five transects were included in the adult and juvenile fish surveys: Douglas Pt, Bruce GS 'B' discharge, Bruce GS 'B' intake, Holmes Bay, and Gunn Pt. McRae Pt was sampled in 1980 and 1981.

During the open water period gill nets were set on bottom at the 3 and 12-m contours for two consecutive 24 h periods, and were fished from May to November. Gill nets consisted of eight or nine 2 m x 20 m panels with stretched mesh sizes of 2.5 cm (1 ") to 12.7 cm (5") or 3.7 cm (1.5") to 12.7 cm. The smallest mesh, 2.5 cm, was added in 1980 and 1981, but was not available for approximately 70% of sets in 1981.

Trap nets were fished at the above transects, with the exception of the Bruce GS 'B' intake transect, from May to October. Paired 1.2 m (4 ft) nets were set for two consecutive 24 h periods, with the boxes at the 2 to 3-m depth. Beach seining was also conducted from May to October; transects were the same as for trap nets in 1979, but in 1980 and 1981 the intake transect, having a safer location for seining, was substituted for the discharge transect. Triplicate hauls were made after dusk; a 15 m, 0.64-cm mesh seine was drawn to shore in a quarter-circle sweep from a depth of 1 to 2 m.

Winter fishing was confined to gill netting which was carried out at the same transects sampled during the open water period.

Winter sampling was conducted in March-April and December, 1981, and in January-February, 1983.

Ichthyoplankton

Sampling depths and transects for ichthyoplankton (larval fish) are shown in Table 2.3-1. In 1979 and 1981 surface samples were collected on six transects at three depth contours, and bottom samples were added on the intake transect.

In 1980 and 1982 only nearshore surface samples, over the 1.0 to 1.5-m depth contour, were collected. From 1979 to 1981 collections generally commenced in mid-May, and proceeded biweekly to late July or August. In 1982 sampling began in late April and was terminated in late June. All samples were taken after dusk.

At each sampling location two 0.5-m conical nets with 363-^{e}m mesh were towed, in tandem, at a constant boat speed for 5 min. The nets were equipped with current meters that were located in the centre of the net opening. Tow velocities were used to calculate volume of lakewater sampled, and average volumes in each year (generally 30 to 40 m^3 per tow) were used to calculate larval densities. Minimal clogging of the net by seston occurred during 5 min. tows.

TABLE 2.3-1

ICHTHYOPLANKTON SAMPLING LOCATIONS, 1979-82 (YEARS 1-4)

Transect	Surface				Bottom	
	1-1.5 m	3 m	7 m	12 m	7 m	12 m
Douglas Pt.	4					
Lagoon Bay	3,4	1,3	1,3	1		
Bruce 'B' Discharge	3,4	1,3	1,3	1		
Bruce 'B' Intake	3,4	1,3	1,3	1	1,3	1,3
S. Boundary Pt.	3,4	1,3	1,3	1		
Holmes Bay	2,3,4	1,3	1,3	1		
Gunn Pt.	3,4	1,3	1,3	1		
Inverhuron Bay	2,4					

Acoustic Fish Census

Acoustic surveys of nearshore fish populations were conducted by day in the following months: June, August and October, 1979; May, July, August, September and November, 1980; June, July, September and November, 1981. Night surveys were obtained within 36 h of the corresponding day surveys in June and October, 1979, July and September, 1980, and June and July, 1981. Surveys were conducted along a grid of transects roughly perpendicular to shore and extending from the 5 to 35-m depth contours. The 1979 grid consisted of seven transects located between Lagoon Bay and South Boundary Point (Figure 2.1-1). The 1980-81 grid was expanded to 13 parallel transects from Douglas Pt. to Gunn Pt. Each transect consisted of approximately 20 data-logging intervals split into 6-m depth shells. Fish echoes were displayed on analogue echograms and counts recorded automatically. Details of equipment, survey methods and data processing are given in OHRD Reports C78-157-K and C79-87-K.

In conjunction with day samples thermal structure was determined from temperature profiles taken at 200-m intervals along the median transect. Additional profiles were taken at the inshore corners of the grid and, in 1979, temperature at the 0.5-m depth was monitored continuously during each survey in an attempt to discern temperature discontinuities that could be related to fish distribution.

Identification of fish species contributing to echoes was attempted by means of 2 to 3 h gill net sets (2.5 to 12.7 cm mesh) at fixed locations along the median transect (1979) or in areas of observed fish concentration (1980 and 1981).

Whitefish Spawning

Whitefish spawning studies were carried out in November and December, 1980 and 1981. In 1980 routine monthly fish surveys were supplemented by December gill netting on the Bruce GS 'B' intake and discharge transects; in 1981 the November and December collections were expanded to include the BNPD transects of MacPherson Bay, Bruce Heavy Water Plant (BHWP), and Scott Point. All whitefish were examined for reproductive condition, weight, fork length and age (from scale annuli).

Feeding and Growth

In 1979 qualitative feeding habits of adults of six fish species was determined from stomachs obtained during routine netting. Sample size varied as follows: yellow perch, 121; longnose sucker, 65; white sucker, 40; white bass, 10; walleye, 10;

rainbow trout, 4. Prey organisms were identified to order, with the exception of fish remains, which were identified to species where possible.

In 1979, fork lengths and scales for age determination were obtained from yellow perch (119), longnose sucker (66), white sucker (40) and walleye (11). Back-calculated growth rates were then determined from age-length data. In 1980 and 1981 round whitefish collected in the fall were measured, weighed and aged.

2.3.5 Nesting Gulls

All terrestrial land-fill and armour-stone habitats at the Bruce GS 'B' site were surveyed visually for the occurrence (number and location) of nesting gulls during May, 1980. This was part of a more extensive search for larid nests that was conducted between Gunn and Scott Points (OHRD Report 82-182-K). Casual observations for evidence of nesting activity at the Bruce GS 'B' site were also made during the springs of 1981 and 1982.

3.0 RESULTS AND DISCUSSION

3.1 Physical and Chemical Characteristics

3.1.1 Substrate

Composite maps of bottom substrate were prepared from photographic data gathered from 1979 to 1982 (Figure 3.1-1 A & B). Shoreline substrate data describe the splash zone, which is normally exposed, but is subject to wave action and periodic deposition and removal of small-particle substrates. The shoreline from Lagoon Bay south to the Bruce GS 'B' intake transect has been modified by the addition of armour stone; natural substrates may be exposed at the base of the armour stone, depending on water levels. A general trend of decreasing shoreline particle size from north to south was seen, with boulder-cobble predominating to Holmes Bay, giving way to gravel-pebble and then sandy beaches in Inverhuron Bay. South of Inverhuron Bay a return to coarser shoreline substrates was seen, with exposed bedrock and boulder-cobble predominant.

Exposed bedrock was the dominant substrate at depths of 1 to 12 m in the northern portion of the study area; it also predominated over much of the remaining area at shallow to moderate depths (1 to 5 m). Although stable, this substrate is relatively featureless, and, with the exception of ledges and fissures, affords little cover for benthic fishes or invertebrates. However, at shallow depths it may be readily colonized by periphyton, which provides additional habitat for benthic invertebrates.

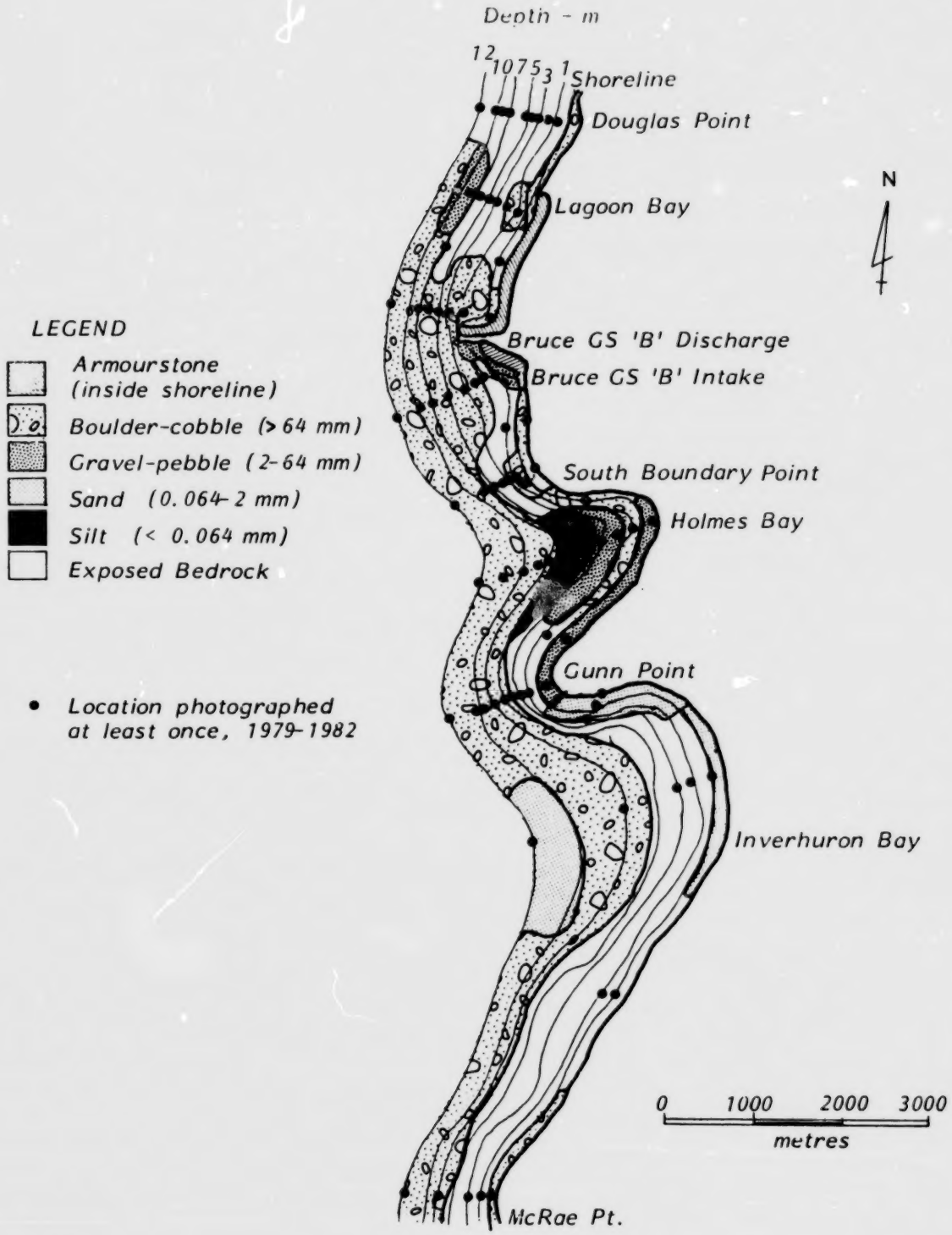


FIGURE 3.1-1

SUBSTRATES AT BRUCE GS 'B' (COMPOSITE, 1979 - 1982)
(A) PREDOMINANT SUBSTRATES

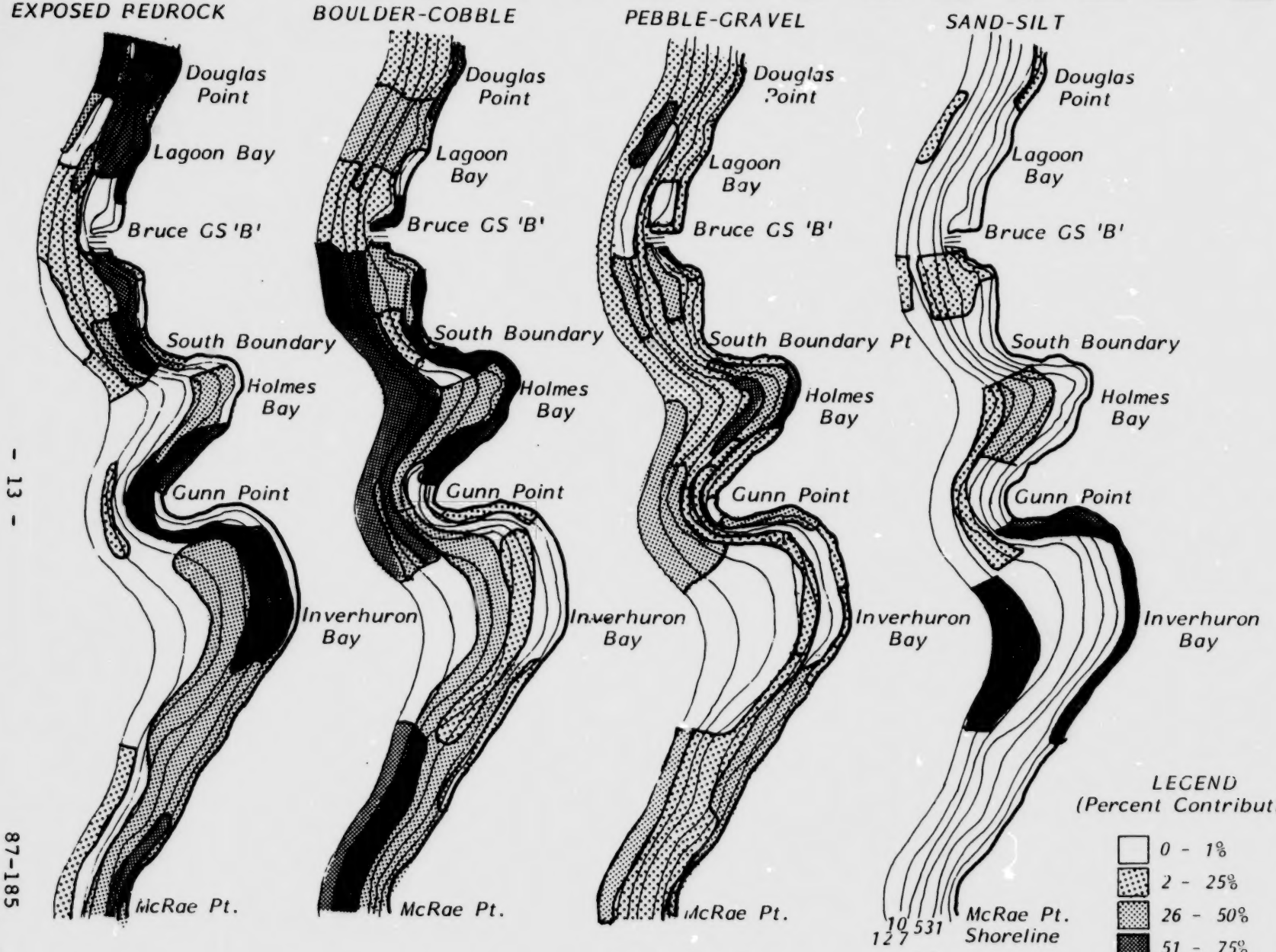


FIGURE 3.1-1

SUBSTRATES AT BRUCE GS 'B' (COMPOSITE, 1979-1982)
(B) DISTRIBUTION OF MAJOR SUBSTRATE CATEGORIES

87-185
167187-RD

Boulder-cobble substrates dominated most of the study area at depths of 7 to 12 m, and were found overlying the bedrock in significant amounts over large areas at shallower depths. Areas dominated by pebble-gravel (2 to 64 mm dia.), in contrast, were restricted to isolated patches at various depths. The largest contiguous area where cover of pebble-gravel substrates exceeded 25% was found in the region of Holmes Bay and Gunn Pt. The distribution of pebble-gravel and boulder-cobble substrates is of particular interest from the viewpoint of potential fish spawning areas, especially for lake trout and whitefish. Substrates ranging from boulder to gravel also provide increased habitat for benthic fauna and are less subject to disturbance caused by strong wave action.

The finer substrates, sand and silt, were largely limited to Holmes and Inverhuron Bays, and varied considerably in their extent from year to year. In Holmes Bay coarse substrates covered by a layer of sand (2 to 5-m contours) or silt (5 to 7-m contours) in 1979 were exposed in 1980. Sand, subject to shifting by currents, is an unstable and inhospitable habitat for most benthic fauna. Silt cover may increase suitability of the substrate for some benthos, but may result in oxygen depletion in the substrate, which would affect fish egg survival. Although areas of sand and silt cover did not occur over large portions of the site, they overlapped the principal areas of medium-sized substrates, and thus could be of concern in terms of fish spawning success.

In 1979 samples of small to fine substrate (<40 mm particle size) were collected and subjected to analysis of particle size and organic content. Finest substrates (mean particle size 0.04 mm) were sampled at the 1-m depth on the Bruce GS 'B' intake transect, while samples collected in Holmes Bay at the 3-m and 7-m depths had mean particle sizes of 0.5 and 0.34 mm. Among these samples, the Bruce GS 'B' intake sample had the highest organic content (loss-on-ignition = 4.07%), while the organic content of the Holmes Bay samples ranged from 0.75% to 1.46%.

3.1.2 Sedimentation

Some sedimentation collection tubes were not recovered, or had been tipped over by the action of storms and nearshore currents. In particular, September - November 1981 samples were often missing. Highest sedimentation rates in all three years generally occurred along the Holmes Bay transect, particularly at the 3-m and 7-m contours during the latest (September - November) sampling period (Table 3.1-1). The relatively high sedimentation rates (inorganic and organic) may be related to a

TABLE 3.1-1

TOTAL SEDIMENTATION RATES (INORGANIC + ORGANIC) IN THE VICINITY AT BRUCE GS 'B', 1979-1981

	Sedimentation Rate ($g/cm^2/day$)		
	1979 Mean ± 1 S.D. (n)	1980 Mean ± 1 S.D. (n)	1981 Mean ± 1 S.D. (n)
(By Period)			
May - July	0.007 ± 0.007 (21)	0.013 ± 0.010 (27)	0.009 ± 0.020 (25)
May - Aug		0.121 ± 0.132 (19)	0.031 ± 0.031 (22)
July - Sept	0.078 ± 0.121 (18)		
Aug - Nov		0.042 ± 0.022 (16)	0.147 ± 0.130 (6)
Sept - Nov			
(By Depth Contour)			
3 m	0.044 ± 0.099 (12)	0.022 ± 0.022 (18)	0.030 ± 0.036 (20)
7 m	0.051 ± 0.116 (14)	0.086 ± 0.120 (21)	0.038 ± 0.079 (17)
12 m	0.022 ± 0.033 (13)	0.049 ± 0.074 (23)	0.035 ± 0.074 (16)
(By Transect)			
Douglas Point	0.016 ± 0.018 (6)	0.014 ± 0.009 (6)	0.009 ± 0.005 (4)
Lagoon Bay	0.037 ± 0.037 (6)	0.029 ± 0.026 (7)	0.011 ± 0.010 (5)
Bruce 'B' Discharge	0.014 ± 0.009 (6)	0.019 ± 0.015 (6)	0.031 ± 0.028 (6)
Bruce 'B' Intake	0.014 ± 0.014 (6)	0.036 ± 0.051 (6)	0.059 ± 0.109 (7)
South Boundary	0.011 ± 0.009 (5)	0.077 ± 0.121 (7)	0.007 ± 0.005 (5)
Holmes Bay	0.155 ± 0.196 (6)	0.105 ± 0.160 (8)	0.029 ± 0.026 (5)
Gunn Point	0.019 ± 0.019 (4)	0.044 ± 0.067 (7)	0.007 ± 0.006 (6)
Inverhuron Bay	Not Sampled	0.074 ± 0.084 (8)	0.036 ± 0.055 (6)
McRae Point	Not Sampled	0.062 ± 0.085 (7)	0.074 ± 0.101 (9)
Overall Mean	0.040 ± 0.089 (39)	0.054 ± 0.087 (62)	0.034 ± 0.063 (53)

reduction in current velocity in the innermost portion of this relatively confined bay. Low sedimentation rates generally occurred in the region of Gunn Pt where alongshore currents may act to reduce deposition. The deposition of inorganic sediments was always lowest during the first sampling period (May - July or August). Higher sedimentation rates in the fall are likely related to an increase in the resuspension of sediments caused by an increase in wind-generated turbulance of the lake.

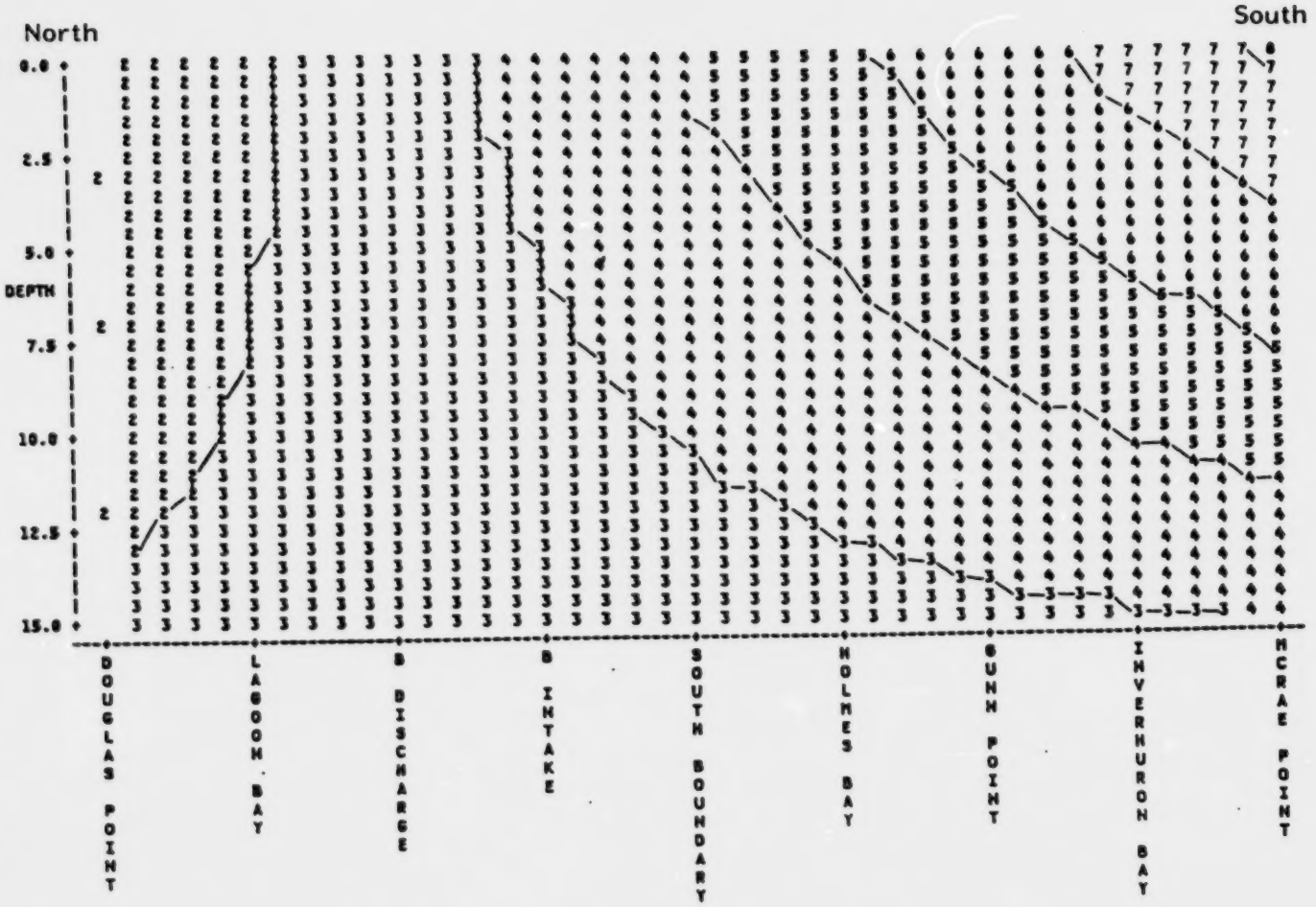
Average sedimentation rates were highest in 1980 and lowest in 1981 (Table 3.1-1). However, considerable variation in sedimentation rates existed within years, seasons, depth contours and transects; coefficients of variation were typically 100% or higher.

A contour plot from a best fit model was used to describe general trends in the spatial distribution of inorganic sedimentation rates for all sampling periods combined (Figure 3.1-2). Highest values were generally found in the inshore regions of the southernmost transects (McRae Pt, Inverhuron Bay), decreasing towards deeper water and towards the more northern locations. Although this model described the overall pattern in inorganic sediment deposition, significant differences in deposition rates did exist between years and months, as well as the illustrated differences between depths (ANOVA, $P < 0.01$). The ANOVA accounted for a significant proportion of the total variation in the data ($r^2 = 0.771$; $F_{63, 91} = 4.86$, $P < 0.01$).

The best fit model, based on all time periods, indicated a general decrease in organic sedimentation rates with increasing lake depth, although the range of fitted values in the model is small (Figure 3.1-3). There was no pattern in organic deposition rates in the alongshore direction. ANOVA showed significant ($P < 0.01$) effects of depth, but not transect differences. Year and period differences were also significant at the 1% level, but a significant interaction term (year x period) was found, making an overall statement of temporal differences invalid. The overall ANOVA statistics were also significant ($r^2 = 0.731$, $F_{63, 91} = 3.92$, $P < 0.01$), indicating that a significant amount of the variation in organic sedimentation rates was explained by factors considered in the model, particularly depth.

Per Cent Organic Content

The proportion of organic matter in sediment tubes was generally high for the Douglas Pt transect, compared to other transects in the Bruce GS 'B' region, over all years (Table 3.1-2). Greatest proportions of organic matter were always found in the first sampling period (May - July or August). Sediment organic content was lowest in the September - November samples in all

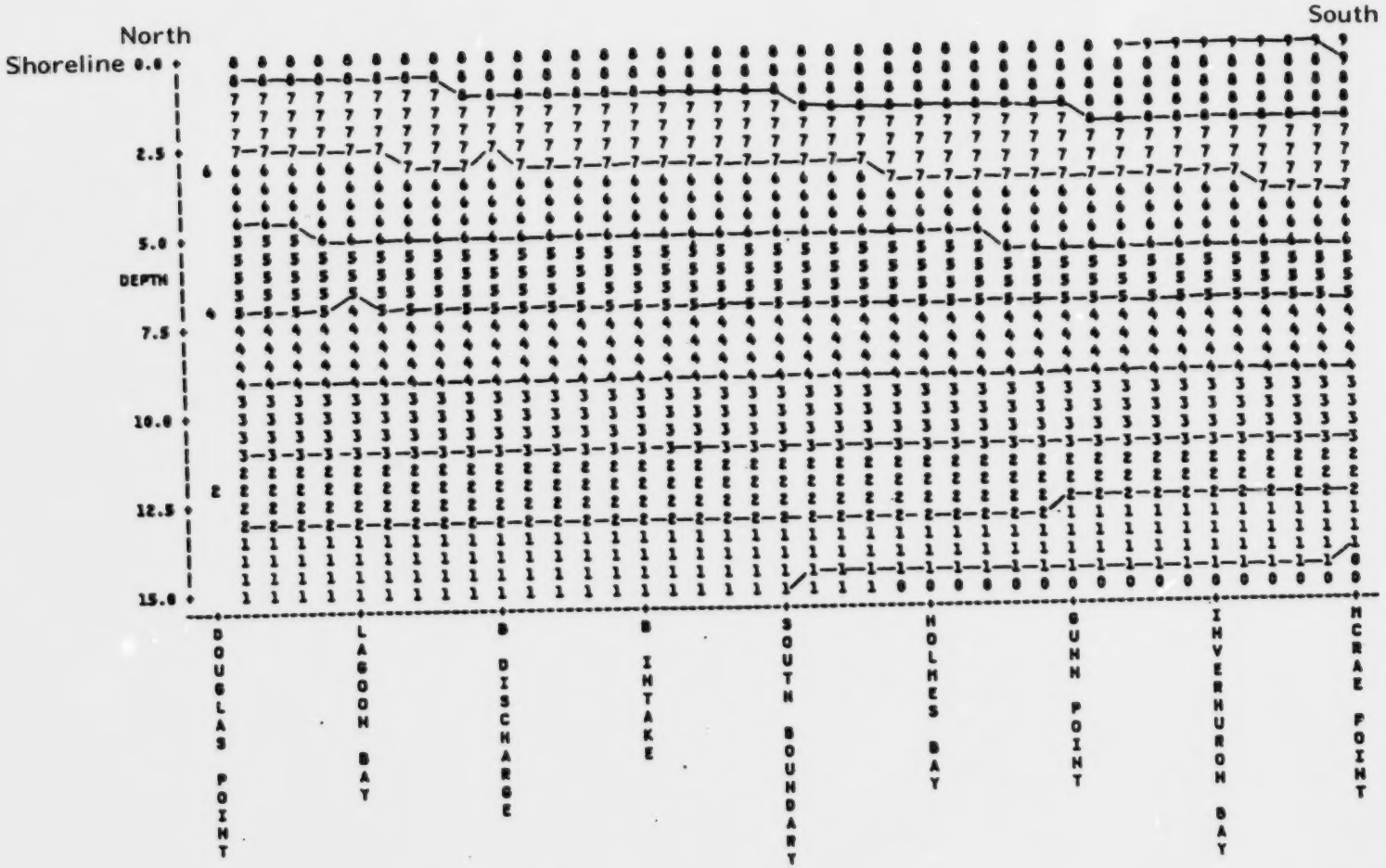


Legend

SYMBOL		SEDIMENT	SYMBOL		SEDIMENT	SYMBOL		SEDIMENT	SYMBOL		SEDIMENT
000000	5.778587 -	5.781005	333333	5.790678 -	5.795515	666666	5.805188 -	5.810024	999999	5.819697 -	5.822116
111111	5.781005 -	5.785842	444444	5.795515 -	5.800351	777777	5.810024 -	5.814861			
222222	5.785842 -	5.790678	555555	5.800351 -	5.805188	888888	5.814861 -	5.819697			

FIGURE 3.1-2

CONTOUR PLOT OF LOG INORGANIC SEDIMENTATION RATES (g/m^2) IN THE VICINITY OF BRUCE GS 'B', 1979 TO 1981



Legend

SYMBOL		SEDIMENT	SYMBOL		SEDIMENT	SYMBOL		SEDIMENT	SYMBOL		SEDIMENT
000000	1.615845 -	1.617259	333333	1.622913 -	1.625740	666666	1.631395 -	1.634222	999999	1.639876 -	1.641290
111111	1.617259 -	1.620086	444444	1.625740 -	1.628567	777777	1.634222 -	1.637049			
222222	1.620086 -	1.622913	555555	1.628567 -	1.631395	888888	1.637049 -	1.639876			

FIGURE 3.1-3

CONTOUR PLOT OF LOG ORGANIC SEDIMENTATION RATES (g/m^2) IN THE VICINITY OF BRUCE GS 'B', 1979 TO 1981

TABLE 3.1-2

PER CENT ORGANIC CONTENT OF SEDIMENTS IN THE VICINITY OF BRUCE GS 'B', 1979-1981

	Percent Organic Content		
	1979	1980	1981
	Mean ± 1 S.D. (n)	Mean ± 1 S.D. (n)	Mean ± 1 S.D. (n)
(By Period)			
ay - July		13.7 ± 8.8 (27)	9.0 ± 3.2 (25)
ay - Aug	7.2 ± 1.8 (21)		
uly - Sept		5.5 ± 3.6 (19)	5.9 ± 1.6 (22)
ug - Nov	5.3 ± 1.4 (17)		
ept - Nov		1.6 ± 0.9 (16)	1.8 ± 0.8 (6)
By Depth Contour)			
3 m	5.8 ± 1.6 (12)	11.3 ± 10.2 (18)	7.4 ± 2.6 (20)
7 m	6.1 ± 2.4 (13)	7.8 ± 8.3 (21)	6.9 ± 2.4 (17)
12 m	7.0 ± 1.5 (13)	5.8 ± 4.5 (23)	6.3 ± 4.9 (16)
(By Transect)			
ouglas Point	6.8 ± 1.2 (5)	12.0 ± 14.0 (6)	8.5 ± 1.1 (4)
agoon Bay	5.8 ± 1.0 (6)	8.6 ± 8.2 (7)	7.1 ± 2.5 (5)
ruce 'B' Discharge	7.0 ± 2.1 (6)	9.0 ± 3.0 (6)	6.9 ± 3.4 (6)
ruce 'B' Intake	7.1 ± 1.9 (6)	7.8 ± 4.1 (6)	5.1 ± 2.8 (7)
outh Boundary	6.9 ± 1.3 (5)	13.0 ± 13.0 (7)	7.1 ± 0.9 (5)
olmes Bay	4.8 ± 1.8 (6)	8.6 ± 9.2 (8)	6.8 ± 2.7 (5)
unn Point	5.8 ± 3.2 (4)	5.6 ± 3.6 (7)	8.8 ± 3.6 (6)
nverhuron Bay	Not Sampled	4.0 ± 3.9 (8)	5.9 ± 2.7 (6)
cRae Point	Not Sampled	5.3 ± 4.0 (7)	6.9 ± 5.9 (9)
verall Mean	6.3 ± 1.9 (38)	8.1 ± 8.0 (62)	6.9 ± 3.4 (53)

three years indicating that organic production within the photic zone did not contribute to fall sedimentation rates to any substantial degree. In 1980 and 1981 sediment organic content decreased in an offshore direction. The reverse pattern was apparent in 1979 although sampling effort in this year was much less. The average organic content of the sediments was 7.2% with somewhat higher and more variable organic content being observed in 1981.

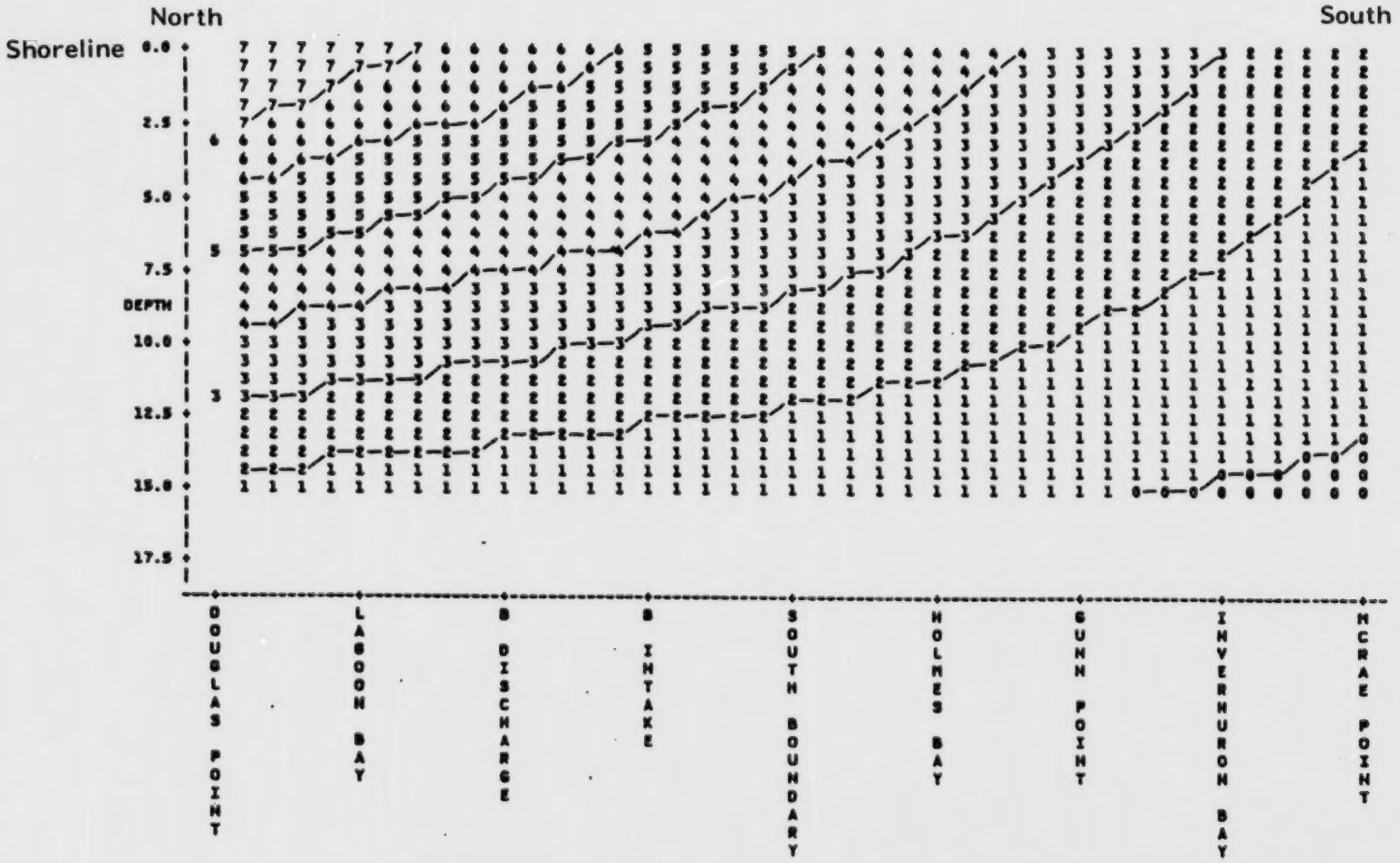
The contour plot derived from modelling, using arc-sine, square values root transformed values from all time periods, indicated that sediment organic content was generally lowest in deep areas of the southernmost transects, and increased towards shallower and more northerly areas (Figure 3.1-4). However, analysis of covariance with a depth covariate did not reveal significant effects due to depth or transect ($P \ll 0.10$). In addition, results were relatively consistent from year to year (insignificant year effect, $P < 0.10$), but significant variability among periods was found ($P < 0.01$). High values were consistently associated with May - July samples, and low values with September - November samples. There was, however, a suggestion of a year x sampling period interaction ($P = 0.0895$), and therefore no conclusions were drawn regarding the temporal distribution of organic content in sediments.

3.1.3 Sediment Chemistry

Common elements present in sediments collected in sediment traps during 1979 included calcium (111 000 - 142 650 mg/kg), aluminum (25 200 - 39 800 mg/kg), iron (13 800 - 24 800 mg/kg), and potassium (9 370 - 13 300 mg/kg) (Table 3.1-3). Many elements were present in highest concentrations in the August sampling period. Notable exceptions were calcium, strontium and uranium which were present in highest concentrations in November. The observed seasonal differences in elemental composition may be related to differences in sedimentation patterns, with high sedimentation rates and relatively low sediment organic content during the fall, as compared to the summer. Observed spatial trends should be considered with caution because of the limited sampling program; calcium concentrations decreased from southerly to northerly transects during August samples, but increased over this same range in November.

3.1.4 Water Temperature, Dissolved Oxygen and Transparency

Limited temperature data from Hydraulic Studies instrument station THB08 (2-m depth) at the Bruce GS 'B' discharge was collected during 1979 while continuous records for the open water period were obtained in 1980 and 1981 (O.H. Hyd. Studies Dev. Dept. Reports 82259, 83336). The location of the



Legend

SYMBOL	SEDIMENT	SYMBOL	SEDIMENT	SYMBOL	SEDIMENT
000000	0.1260056 - 0.1262287	444444	0.1275674 - 0.1280137	888888	0.1293524 - 0.1297987
111111	0.1262287 - 0.1266749	555555	0.1280137 - 0.1284599	999999	0.1297987 - 0.1302218
222222	0.1266749 - 0.1271212	666666	0.1284599 - 0.1289062		
333333	0.1271212 - 0.1275674	777777	0.1289062 - 0.1293524		

FIGURE 3.1-4

CONTOUR PLOT OF PERCENT ORGANIC CONTENT
(ARC-SINE, SQUARE ROOT TRANSFORMATION), IN SEDIMENTS OF THE
BRUCE GS 'B' REGION, 1979 TO 1981

TABLE 3.1-3

CHEMICAL ANALYSIS (mg/kg - dry basis) OF SEDIMENTS COLLECTED

IN SEDIMENT TRAPS, BRUCE GS 'B' - 1979

	August				November			
	Douglas Point	Bruce 'B' Discharge	South Boundary	Gunn Point	Douglas Point	Bruce 'B' Discharge	South Boundary	Gunn Point
Analysis	7 m	7 m	7 m	7 m	7 m	7 m	7 m	7 m
Aluminum	33 300	38 500	39 800	35 050	25 200	34 300	26 400	26 200
Arsenic*	6.3	8.7	7.4	5.7	3.0	3.5	3.6	2.6
Barium	270	288	357	256	260	300	260	280
Beryllium*	0.18	0.15	0.20	0.15	0.14	0.12	0.10	0.13
Bromine	32	29	34	32	26	27	23	18
Calcium	111 000	112 400	116 500	119 300	142 650	139 900	134 700	123 100
Cadmium*	<2	3.1	2.5	3.4	0.5	0.50	<0.50	0.70
Cerium	36	38	42	37	30	42	30	31
Chlorine	160	457	430	232	200	240	300	300
Cobalt*	7.9	9.4	9.1	8.3	5.6	6.8	5.6	5.6
Chromium*	66	57	47	39	30	36	31	33
Cesium	2.0	2.4	2.7	2.2	1.5	1.8	1.4	1.2
Copper*	26	32	25	29	14	16	12	12
Dysprosium	0.80	0.73	0.90	0.70	0.60	0.5	0.5	0.6
Europium	0.56	0.65	0.73	0.64	0.50	0.60	0.50	0.50
Iron*	17 000	24 800	20 050	21 500	13 800	18 200	15 300	15 700
Hafnium	3.4	4.1	4.3	3.5	3.7	5.1	3.4	4.6
Mercury*	0.36	0.43	0.27	0.35	0.13	0.08	0.08	0.09
Iodine	6.5	5.4	5.6	6.2	3.5	4.8	8.7	3.0
Potassium	12 900	13 200	13 300	12 100	9 370	10 450	9 700	10 400
Lanthanum	16	19	18	15	14	19	14	13
Lutetium	0.16	0.18	0.32	0.16	0.20	0.2	0.2	0.2
Manganese*	286	303	295	263	300	303	300	280
Sodium	4210	4340	4550	4100	4430	4980	5100	5800
Nickel*	20	35	19	21	11	15	10	14
Lead*	<10	<10	32	<10	11	22	7	11
Rubidium	53	62	69	59	46	56	44	45
Antimony	0.60	1.5	1.3	3.0	0.20	0.30	0.20	0.30
Scandium	6.0	6.8	7.1	6.3	5.0	5.8	5.0	5.1
Selenium*	1.4	1.1	1.7	0.8	0.50	0.60	0.40	0.40
Samarium	3.0	3.1	2.8	2.9	2.3	2.8	2.4	2.4
Strontium	196	135	155	234	340	280	430	530
Tantalum	0.35	0.45	0.50	0.40	0.30	0.40	0.30	0.30
Terbium	0.36	0.40	0.42	0.36	0.30	0.40	0.30	0.30
Thorium	4.7	5.1	5.6	4.8	3.3	4.4	3.3	3.5
Titanium	1950	2035	1540	1710	1915	1630	1400	1000
Uranium	0.72	0.90	2.0	0.83	3.2	5.0	6.0	5.0
Vanadium*	50	54	55	48	27	42	20	34
Ytterbium	1.0	1.1	1.3	1.1	1.0	1.1	1.0	1.1
Zinc*	70	83	72	70	54	53	45	49

* Requested Chemical Analysis

instrument was removed from the main influence of thermal plumes associated with other sites and BNPD although the Douglas Point plume may have reached this location on some occasions. A cubic spline function with continuous second derivatives was used to fit lines to the data from 1980 and 1981, while available 1979 data are plotted as points (Figure 3.1-5). The fitted lines pass through all data points.

A number of sudden temperature drops, corresponding to cold-water upwellings, were apparent during 1980 and 1981. Upwellings were particularly evident in August and September of 1981, when temperatures decreased by as much as 16°C over a period of a few days, before returning (with similar rapidity) to 'normal' seasonal values. Variability in early season (May - August) temperatures between years was greater than the variability generally observed during the September - December period.

Temperature and dissolved oxygen profiles recorded at Gunn Pt and Bruce GS 'B' intake 12 m spars showed little variation with depth, and were similar for both sites, on nearly all occasions in 1979 and 1981. Little indication of thermocline formation was apparent in either year at this depth; decreases in temperature were observed at the 7 - 10 m level in late August 1979 (Bruce GS 'B' intake only), and 1981 (both locations). The 1981 profile readings (August 20) apparently coincide with an upwelling event (Figure 3.1-5). Maximum isothermal temperatures occurred on July 9, 1981.

Dissolved oxygen maxima were recorded in June (1979) and July (1980), with values of 12 - 13 mg/L. Concentrations of dissolved oxygen were always in excess of 9 mg/L at all depths and times, and were, therefore, at or above saturation levels.

Transparency (Secchi disc) readings obtained in 1979 were compared to readings taken in 1981 at plankton sampling grid points (Table 3.1-3; OHRD Report 83-451-K). Mean transparency readings in 1979 ranged from a low of 1.75 m in May, to a high of 6.0 m in October. Results from 1981 readings in the same area were generally higher, ranging from 5.3 m to 8.0 m between July and October. Transparency readings increased with distance from shore in 1981, with the exception of October samples which usually showed decreased transparency 2 km from shore.

3.1.5 Water Chemistry

Water chemistry was summarized as monthly and yearly means for all parameters in Table 3.1-4. The first eight parameters listed were sampled in all three years. Year-to-year variation was slight in the case of pH, conductivity, and non-filtrable residues (formerly dissolved solids). The values for turbidity

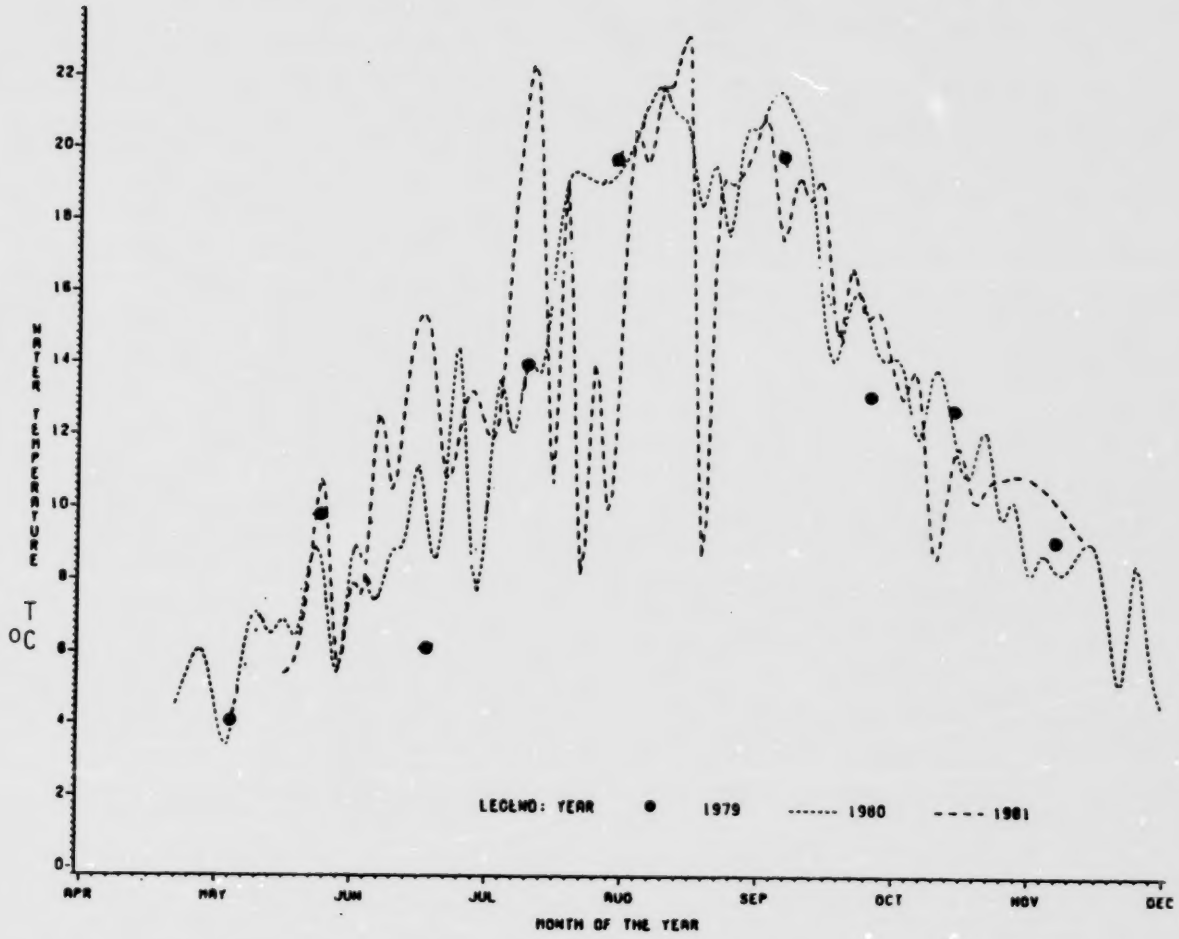


FIGURE 3.1-5

TEMPERATURE RECORDS NEAR THE BRUCE GS 'B'
DISCHARGE LOCATION, 1979 TO 1981

TABLE 3.1-4

SUMMARY OF WATER CHEMISTRY AT BRUCE GS 'B' SHOWING MEAN VALUES BY MONTH AND YEAR

Parameter	Monthly Means (1979 - 81)						Yearly Means			Range in Detection Limits+
	M	J	J	A	S	O-N	1979	1980	1981	
pH	8.2	8.1	8.1	8.3	8.3	7.8	7.9	8.3	8.0	
Conductivity (mS/m)	20.3	19.8	19.8	19.1	19.1	19.4	19.3	20.5	18.8	
Turbidity (NTU)	0.79	0.88	0.89	0.58	1.14	1.25	0.89	0.67	1.20	
Filtrable Residues (mg/L)										
Volatile (105°C)	1.55	1.37	<1.17	<1.07	<1.12	<1.56	1.03	<1.08	<1.82	0.2-1.0
Non-Volatile (550°C)	<0.91	<0.80	<0.80	<0.85	<1.07	<1.47	0.50	<0.79	<1.27	0.2-1.0
Non-Filtrable Residues (mg/L)										
Voltatile (105°C)	125	119	124	134	119	120	118	125	125	
Non-Volatile (550°C)	102	93	101	105	92	103	96	99	97	
Chemical Oxygen Demand (mg/L)	<7.2	<5.8	15.5	<5.0	<7.1	<6.8	8.48	<7.8	<5.7	2-5
Biological Oxygen Deman (mg/L)	2.0	<1.0	<0.9	<0.9	<1.0	<1.2	-	1.3	1.1	0.5-1
Chlorophyll a (µg/L)	<0.5	1.4	1.1	<0.4	1.6	1.3	<0.7	-	<1.4	0.3-0.5
Alkalinity (mg/L as $CaCO_3$)	-	78.4	-	28.3	-	77.5	78.1	-	-	
Hardness (mg/L as $CaCO_3$)	-	90.3	-	92.6	-	91.7	91.8	-	-	
Total Organic Carbon (mg/L as C)	-	1.4	-	1.4	-	<1	<1.3	-	-	1.0
Total Phosphorus (µg/L)*	<7.5	14.0	<7.0	<9.5	11.0	6.2	-	-	<9.1	<5-5
Ortho Phosphorus (µg/L)*	<7.5	8.0	<5.3	<5.0	8.8	<5.3	-	-	<6.7	5
Soluble Phosphorus (µg/L)*	<5.0	8.3	<6.0	<5.0	8.5	4.6	-	-	<6.2	<2-5
Total Kjeldahl Nitrogen (mg/L as N)	0.55	0.62	0.18	0.38	0.12	0.23	0.43	-	0.34	
Soluble Nitrogen (mg/L as N)	0.45	0.39	0.16	0.21	0.14	0.10	0.14	-	0.26	
Nitrite Nitrogen (mg/L as NO_2)	<0.01	<0.01	<0.01	<1.3	<0.01	<0.2	<1.2	-	<0.01	0.01-3
Nitrate Nitrogen (mg/L as NO_3)	1.7	1.2	1.2	1.1	1.1	1.1	1.1	-	1.3	
Ammonia (mg/L as NH_3)	<0.01	<0.02	<0.01	<0.04	<0.01	<0.03	<0.045	-	<0.01	0.01-0.02
Total Silica (mg/L as SiO_2)	1.55	1.36	1.75	1.25	1.42	1.30	1.26	-	1.46	
Dissolved Silica (mg/L as SiO_2)	1.23	0.65	1.09	0.97	1.16	0.94	0.80	-	1.03	
Sulphate (mg/L)	-	15.4	-	14.7	-	15.7	15.3	-	-	
Calcium (mg/L)	26.0	25.9	26.8	26.7	27.5	24.7	25.3	-	26.5	
Magnesium (mg/L)	6.9	6.9	7.3	7.0	7.1	7.1	7.0	-	7.1	
Aluminum (mg/L)	-	<4.0	-	<4.0	-	<4.0	<4.0	-	-	4.0
Potassium (mg/L)	-	0.91	-	1.07	-	0.80	0.92	-	-	
Iron: Total (mg/L)	-	<0.5	-	<0.5	-	<0.5	<0.5	-	-	0.5
Dissolved (mg/L)	-	<0.5	-	<0.5	-	<0.5	<0.5	-	-	0.5
Sodium (mg/L)	-	3.4	-	3.5	-	3.48	3.48	-	-	

* Data for phosphorus from 1981 only; 1979 limit of detection for June and August was 10 µg/L

\+ Detection limits vary; when one or more values were reported as less than the detection limit, the detection limit was used to calculate the mean. These means are preceded by the symbol <.

and filtrable residues (formerly suspended solids) tended to be higher in 1981 than in the previous two years, which may have reflected differences in timing of sampling (i.e. in relation to storms), rather than a real decrease in water clarity. Chemical oxygen demand appeared to decrease from 1979 to 1981, but this trend may have reflected a change in the analytical procedure for this parameter.

An additional 14 parameters were measured in 1979 and 1981; these included two or more forms of the nutrients phosphorus, nitrogen and silicon, as well as calcium and magnesium. Chlorophyll *a*, phosphorus (three forms), nitrite nitrogen and ammonia, which are generally high in enriched environments, were often below detection limits in the Bruce GS 'B' samples.

The data suggested that seasonal trends existed for some chemical parameters (Table 3.1-4). Turbidity levels were highest from September to November which was consistent with the relatively high sedimentation rates that occurred during this period. Values for silica were generally lowest in June or August possibly indicating a depletion of this nutrient by phytoplankton (diatom) uptake. Replenishment of dissolved silica in July may have occurred as a result of upwelling activity (Schelske *et al* 1971). In 1979 the concentration of dissolved silica was inversely related to the density of diatoms (Baccilariophyta). Chlorophyll *a* and phosphorus (total, ortho, soluble) tended to be highest in late spring (June) and late summer (September). Levels of total Kjeldahl nitrogen, soluble-N and nitrate-N tended to be highest in the spring (May-June).

Few obvious differences in mean values were found among sampling locations (Table 3.1-5). As expected, turbidity was lower in offshore surface (12-m contour, intake transect and 7-m contour, discharge transect) than in inshore surface (3-m contour, discharge transect) or bottom (12-m contour, intake transect) samples. The bottom samples were slightly richer in silica (total and dissolved), which may reflect resuspension of sediments close to the substrate.

Water quality criteria for unpolluted waters were available for some of the parameters investigated (Ontario Ministry of the Environment Publications 1978, 1981). Ratios of non-filtrable residues (dissolved solids):conductivity, calcium:magnesium and sodium:potassium were within normal ranges (0.65 $\pm$ 0.1:1, 3-5:1 and 2-3:1, respectively) for natural, unpolluted waters; non-filtrable residue and ammonia levels were well below the criteria for drinking water (<500 mg/L and 0.02 mg/L). Levels of the nutrient phosphorus averaged less than the 20 g/L considered adequate to protect against nuisance algal growth.

TABLE 3.1-5

SUMMARY OF WATER CHEMISTRY SHOWING MEAN VALUES BY LOCATION, 1979 TO 1981

Parameter	Intake Transect		Discharge Transect	
	12-m Surface	12-m Bottom	3-m Surface	7-m Surface
pH	8.1	8.1	8.1	8.2
Conductivity (ms/m)	20.0	19.5	19.5	19.3
Turbidity (NTU)	0.85	0.99	0.98	0.87
Filtrable Residues (mg/L)				
Volatile (105°C)	<1.16	<1.69	<1.39	<1.29
Non-Volatile (550°C)	<0.87	<0.87	<1.0	<0.98
Non-Filtrable Residues (mg/L)				
Voltatile (105°C)	121	121	127	123
Non-Volatile (550°C)	98	96	100	98
Chemical Oxygen Demand (mg/L)	<6.4	<6.5	<7.7	<7.1
Biological Oxygen Demand (mg/L)	<1.3	<1.2	<1.2	<1.0
Chlorophyll a (µg/L)	<1.1	<0.9	<1.0	<1.0
Alkalinity (mg/L as $CaCo_3$)	77.4	78.4	78.5	-
Hardness (mg/L as $CaCo_3$)	91.8	91.4	92.1	-
Total Organic Carbon (mg/L as C)				
Total Phosphorus (µg/L)	<10.2	<10.4	<7.7	<8.5
Ortho Phosphorus (µg/L)	<6.2	<7.8	<5.1	<7.0
Soluble Phosphorus (µg/L)	<5.9	<7.4	<5.5	<6.2
Total Kjeldahl Nitrogen (mg/L as N)	0.38	0.37	0.38	0.32
Soluble Nitrogen (mg/L as N)	0.22	0.24	0.22	0.24
Nitrite Nitrogen (mg/L as NO_2)	<0.4	<0.4	<0.4	<0.4
Nitrate Nitrogen (mg/L as NO_3)	1.2	1.2	1.2	1.3
Ammonia (mg/L as NH_3)	<0.02	<0.02	<0.02	<0.01
Total Silica (mg/L as SiO_2)	1.40	1.56	1.32	1.30
Dissolved Silica (mg/L as SiO_2)	0.93	1.03	0.92	0.99
Sulphate (mg/L)	15.7	14.8	15.7	-
Calcium (mg/L)	25.9	26.3	26.1	26.3
Magnesium (mg/L)	7.1	7.0	7.0	7.1
Aluminum (mg/L)	<0.4	<0.4	<0.4	<0.4
Potassium (mg/L)	0.97	0.90	<0.91	-
Iron: Total (mg/L)	<0.15	<0.5	<0.5	-
Dissolved (mg/L)	<0.15	<0.5	<0.5	-
Sodium (mg/L)	3.48	3.45		

Several parameters measured here have also been investigated in other areas of north-western Lake Huron. These included total nitrogen, sulphate, conductivity, non-filtrable residues (Ross and Chatterjee 1977) and nitrate (Dobson *et al* 1974). Values obtained in those studies for these parameters were quite similar to those obtained at Bruce GS 'B'. There was also general agreement of Bruce GS 'B' and BNPD (postoperational) values for 21 common parameters.

3.2 Biological Characteristics

3.2.1 Phytoplankton

Since only one year of plankton sampling data were analyzed, no evaluation could be made of either year-to-year variation, or constancy of annual trends in plankton densities. Results from 1979 are summarized briefly below. In-depth treatment of these data may be found in OHRD Report 83-182-K.

Densities of the six phytoplankton divisions for the three sampling periods are shown in Table 3.2-1. Total phytoplankton biomass (mg/m^3) was highest in June samples where the mean biomass was 1 145 mg/m^3, which corresponded with the peak in

TABLE 3.2-1

MEAN DENSITIES (mg/m^3) OF PHYTOPLANKTON AT BRUCE GS 'B' IN 1979

Taxonomic Division	June 6	August 23	October 4
Cyanophyta (Blue Green)	0.6	3.4	55.4
Chlorophyta (Green)	1.1	12.3	5.1
Bacillariophyta (Diatoms)	1130.0	98.5	38.6
Chrysophyta (Golden)	7.8	2.3	20.1
Cryphophyta	5.4	1.6	13.6
Pyrrophyta (Dinoflagellates)		4.7	25.0
Mean Total Biomass	1144.9	122.8	157.8

chlorophyll *a* concentrations that occurred during this month. This density of biomass is an order of magnitude greater than August and October means, and corresponds to the well-documented spring diatom increase (Russel-Hunter 1970).

Bacillariophyta (diatoms) were the dominant group in June and August samples, while Cyanophyta (blue-green algae) were most common in October. Common genera included *Rhizosolenia* and *Tabellaria* in June, unidentified *Pennales* in August, and the blue-green alga *Chrococcus* in October. *Tabellaria fenestrata*, which was common on all dates, was reported by Brown (1978) to be one of the two main nearshore taxa in northwestern Lake Huron.

Phytoplankton assemblages were formed by independent Mutual Information Analyses of data from each of the three sampling dates. In June, the dominant assemblage (22 of 28 samples) was characterized by high abundance of *Rhizosolenia*. Unidentified *Pennales* were characteristic of the dominant August assemblage, and the blue-green algae *(Chrococcus)* dominated the most common October assemblage. Surface water temperature, and spatial trends in the distribution of assemblages on each date, did not appear to be related.

3.2.2 Zooplankton

Zooplankton were sampled on the same grid and schedule as phytoplankton. Mean densities of principal rotiferan and cladoceran taxa on the three sampling dates are shown in Table 3.2-2.

Rotifers:

The rotifer genera *Synchaeta* and *Notholca* contributed to the high overall mean rotifer density (9 732/m^3) in June. These have been described as typical winter-spring taxa (Hutchinson 1967). In August, *Conochilus unicornis* was most abundant, and in October *Keratella cochlearis* and *Polyarthra dolichoptera* were most abundant. All these taxa are common temperate Great Lakes rotifers (Nauwerck 1978).

Crustaceans:

Crustacean zooplankton were found in greatest mean density in August (13 680/m^3) and were least common in June (4 708/m^3).

In June, most of these crustacean plankton were calanoid copepod nauplii larvae (83%), and in August and October, respectively, 57% and 62% of the crustacean zooplankton were calanoid nauplii and copepodites. *Diaptomus minutus* was the most common calanoid species present on all sampling dates.

TABLE 3.2-2

MEAN DENSITIES (No /m^3) OF PRINCIPAL ZOOPLANKTON TAXA AT BRUCE GS 'B' IN 1979

	June 6	August 23	October 4
Rotifers:			
Keratella cochlearis	562.5	346.4	2703.6
Notholca squamula	1214.3	10.7	
Notholca foliacea	410.7	14.3	3.6
Kellicottia longispina	401.8	492.9	696.6
Polyarthra spp	142.9	107.1	207.1
Polyarthra dolichoptera	53.6	532.1	2339.3
Polyarthra vulgaris	160.7	39.3	1317.9
Synchaeta spp	4696.4	42.9	
Synchaeta oblonga	1017.9		28.6
Synchaeta pectinata	866.1	364.3	289.3
Ploesoma truncatum			664.3
Conochilus unicornis		3617.9	264.3
Asplanchna spp	8.9	535.7	60.7
Others (16 taxa)	758.8	32.1	449.9
Total Rotifers	9732.1	6135.7	9025.2
Crustaceans			
Cladocera:			
Holopedium gibberum	2.9	299.3	34.3
Daphnia galeata mendotae		1060.7	129.3
Bosmina longirostris	13.6	267.1	79.3
Eubosmina coregoni	0.7	90.0	28.6
Polyphemus pediculus	0.7	137.9	
Calanoida:			
Diaptomus minutus	23.6	1750.7	150.7
Calanoid nauplii	3883.9	4928.6	1617.9
Calanoid copepodites (CI-CV)	457.1	2857.1	3144.5
Cyclopoida:			
Cyclops bicuspidatus thomasi	133.6	1882.9	2015.0
Cyclopoid nauplii	178.6	378.6	371.4
Other Crustacea (11 taxa)	12.8	27.2	128.6
Total Crustacea	4707.5	13680.1	7699.6
Excluding nauplii and copeodites	187.9	5515.8	2565.8

Cladocerans were most common in August, as is generally found for these taxa (Patalas 1972). *Bosmina longirostris* was most common in June, while *Daphnia galeata mendotae* was most common in August and October. The most common cyclopoid copepod on all three sampling dates was *Cyclops biscuspidatus thomasi*, as was reported by Watson and Carpenter (1974) for Lake Huron in 1971.

Mutual information analyses of the three temporal sets of samples identified the presence of only two assemblages which occurred over all sampling dates. The predominant assemblage, dominated by calanoid copepodites, represented 80 of all samples collected. Assemblage distribution at Bruce GS 'B' was not related to surface water temperatures, depths or spatial orientation.

3.2.3 Attached Algae

Taxonomic Composition and Distribution

Similar numbers of attached algal taxa were collected in 1979 (19) and 1981 (20, Table 3.2-3). Of these totals, six of the 1979 taxa were epiphytic, as were three of the 20 taxa occurring in 1981.

Chaetonema, *Protoderma*, and *Dicothrix* were collected only in 1979, while *Bulbochaete*, *Rhizoclonium*, and *Calothrix* were found only in 1981. Taxonomic difficulties may in part be responsible for this apparent change in species composition; *Dicothrix* and *Calothrix* have very similar morphologies, and *Rhizoclonium* is similar to *Cladophora*, a taxon that did occur in 1979.

Shoreline Algae:

Ulothrix was the most commonly occurring alga at shoreline locations in June of both 1979 and 1981 (Table 3.2-4). This genus was dominant in most locations where shoreline algae occurred, except at Lagoon Bay in 1979, where *Cladophora* was most common in June samples.

In August of 1979, few algae were in evidence at most shoreline locations, with exceptional spot occurrences of *Mougeotia* at Douglas Pt, and some *Ulothrix* at Gunn Pt. In 1981, algae were generally more common during this period. *Bulbochaete* and *Mougeotia* were the most widespread common taxa, and *Ulothrix* occurred in the Bruce GS 'B' discharge location. This latter occurrence is of interest because water temperature readings from this sampling station were higher (20°C) than temperatures previously associated with occurrence of this species (OHRD Report 83-451-K). *Ulothrix* abundance generally decreases in the

TABLE 3.2-3

OCCURRENCE OF ATTACHED AND EPIPHYTIC ALGAL TAXA
AT BRUCE GS 'B' IN 1979 AND 1981

Attached Algae			Epiphytes		
Taxon	1979	1981	Taxon	1979	1981
Bulbochaete		X	*Cocconeis*	X	X
Calothrix		X	*Cymbella*	X	X
Chaetonema	X		*Gomphonema*	X	
Cladophora glomerata	X	X	*Pennales*	X	
Cladophora sp.	X	X	*Rhoiocosphenia curvata*	X	
Coleochaete		X	*Synedra*	X	X
Cylindrospermum		X			
Dicothrix	X				
Draparnaldia		X			
Lyngbya	X				
Mougeotia	X	X			
Oedogonium	X	X			
Pithophora	X				
Plectonema		X			
Protoderma	X				
Rhizoclonium		X			
Schizothrix		X			
Spirogyra	X	X			
Stigeoclonium		X			
Ulothrix zonata	X	X			
Ulothrix sp.	X	X			
Zygnema	X	X			

TABLE 3.2-4

SHORELINE ALGAE AT BRUCE GS 'B' IN 1979 AND 1981

Dominant Taxa	1979		1981	
Epilithic Forms				
June	*Ulothrix*	widespread	*Ulothrix*	widespread
August	*Mougeotia*	local occurrences	*Bulbochaete*	widespread
			Mougeotia	widespread
			Ulothrix	local occurrences
Oct - Nov	*Mougeotia*	widespread	*Ulothrix*	widespread
	Cladophora	local occurrences	*Calothrix*	local occurrences
	Chaetonema	local occurrences	*Cylindrospermum*	local occurrences
Epiphytic Forms				
June	*Gomphonema*	widespread	*Cymbella*	widespread
	Synecha	local occurrences	*Rhoicosphenia*	local occurrences
	Cocconeis	local occurrences		
	Cymbella	local occurrences		
	Rhoicosphenia	local occurrences		
August	*Cymbella*	widespread	*Cocconeis*	widespread
	Gomphonema	local occurrences	*Cymbella*	local occurrences
	Pennales	local occurrences	*Rhoicosphenia*	local occurrences
Oct - Nov	*Cymbella*	widespread	*Cymbella*	widespread
	Gomphonema	local occurrences		
	Pennales	local occurrences		
	Cocconeis	local occurrences		

summer months due to high temperatures (Kirby and Dunford 1981). Late autumn sampling in October (1979) or November (1981) revealed considerable differences in algal composition between years. As in August of 1979, *Mougeotia* remained the most common epibenthic taxon, with local dominance by - *Cladophora* (Bruce GS 'B' intake) and *Chaetonema* (Gunn Pt). However, in 1981, *Ulothrix spp* and *U. zonata* were dominant in the autumn samples, as they were in June samples from both years. *Calothrix* and *Cylindrospermum* occurred in November 1981.

Seasonal trends in species composition may be summarized as follows: In 1979, early season (June) samples were dominated by *Ulothrix*, giving way to *Mougeotia* in August, as water temperatures increased. *Mougeotia* dominance continued in October at most sites. This contrasted with the seasonal dominance spectrum observed in 1981, when *Ulothrix*, dominant in June, was replaced by *Bulbochaete* (with some *Mougeotia*) in August. Late autumn (November) samples were once more characterized by *Ulothrix*. Summer storms observed in 1979 and the later fall sampling in 1981 may have contributed to this change in seasonal dominance between years.

Shoreline epiphytes present in June of 1979 included five taxa, of which only *Gomphonema* was widespread. *Cymbella* and *Rhoicosphenia* were the only epiphytic algae collected in June 1981 (Table 3.2-4). Three taxa were found in August of both years: *Cymbella*, *Gomphonema* and *Pennales* in 1979, and *Cocconeis*, *Cymbella*, and *Rhoicosphenia* in 1981. *Cymbella* was common in autumn samples of both years and was the only epiphyte found in all collections. Epiphytes were generally more diverse in 1979 (mean monthly taxonomic richness = 4.0) than in 1981 (mean richness = 2.0). The reasons for this apparent decline in richness are unknown.

Algae at 3 m Depth:

In 1979 no attached algae were collected in June (Table 3.2-5), and in August *Mougeotia* was collected only at the Bruce GS 'B' intake and discharge 3-m spars. Algae were more abundant and diverse in October samples; *Mougeotia* was dominant, *Cladophora* and *Chaetonema* were also found. No algae were collected at this time at Holmes Bay, South Boundary, or Gunn Pt.

Zygnema was a dominant attached alga in June 1981, except at the Bruce GS 'B' intake (where *Ulothrix* was abundant), and at South Boundary, where no algae were found. In August, *Mougeotia* was dominant, although *Zygnema* (at Gunn Pt) and *Spirogyra* - (Bruce GS 'B' intake and discharge) were also common locally. The greatest algal abundance and variety occurred in November, when *Bulbochaete*, *Mougeotia*, and *Rhizoclonium* each dominated several sites, and *Calothrix* was dominant at one site.

TABLE 3.2-5

ALGAE AT THE 3-m DEPTH AT BRUCE 'B' GS IN 1979 AND 1981

Dominant Taxa	1979		1981	
Epilithic Forms				
June	No algae		*Zygnema* *Ulothrix*	widespread local occurrences
August	*Mougeotia* Sparse algae	local occurrences	*Mougeotia* *Zygnema* *Spirogyra*	widespread local occurrences local occurrences
Oct - Nov	*Mougeotia* *Cladophora* *Chaetonema* Sparse algae	local occurrences local occurrences local occurrences	*Bulbochaete* *Mougeotia* *Rhizoclonium* *Calothrix*	local occurrences local occurrences local occurrences local occurrences
Epiphytic Forms				
June	No algae		*Cymbella* *Cocconeis* *Rhoicosphenia*	widespread local occurrences local occurrences
August	Sparse algae *Gomphonema* *Pennales*	 local occurrences local occurrences	*Cymbella* *Cocconeis*	widespread local occurrences
Oct - Nov	Sparse algae *Pennales* *Cymbella* *Gomphonema*	 local occurrences local occurrences local occurrences	*Cymbella*	widespread

Algal occurrence and variety was maximal in late autumn samples in both years. June was associated with patchy occurrences, including samples with no algae at some (1981) or all sites (1979). Where algae were present in August, *Mougeotia* was generally the most common taxon in both years.

As was observed for attached algae, occurrence of epiphytes was considerably restricted in June and August 1979, while epiphytic algae were more widespread in 1981. No epiphytes were collected in June 1979, though *Cymbella*, *Cocconeis* and *Rhoicosphenia* were common in 1981 during this period. Epiphytic communities of August also contrasted: *Cymbella* was collected at most sites in 1981, while in 1979 only two occurrences were noted, *Gomphonema* at Bruce GS 'B' discharge, and *Pennales* at the intake of Bruce GS 'B'. In October 1979, only a minority of the 3-m samples (3) contained epiphytic taxa *(Pennales, Gomphonema, Cymbella)*, while November 1981 sampling found only *Cymbella*, which occurred at most sites (Table 3.2-5).

Biomass

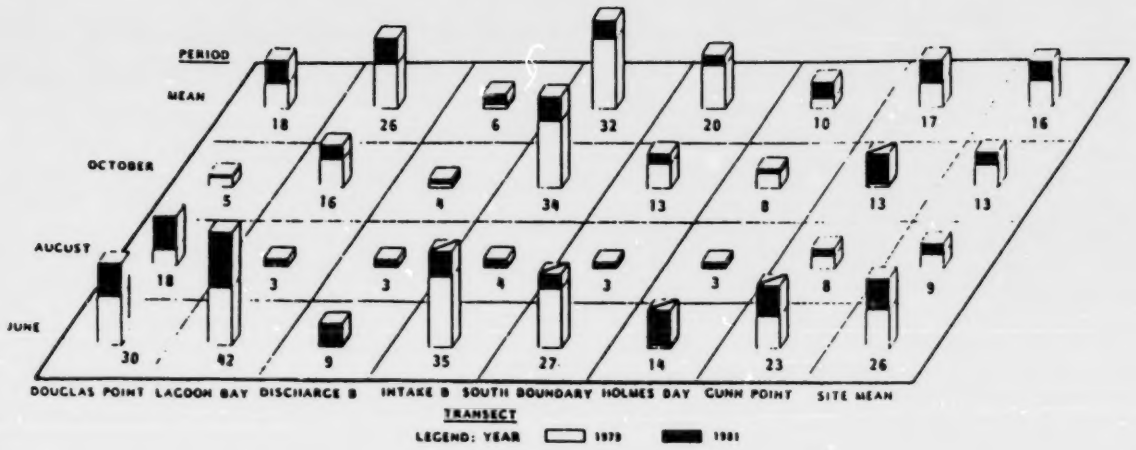
In 1981, some algal samples contained significant amounts of detritus (OHRD Report 83-451-K) which gave inflated estimates of organic matter when the samples were ashed. Mean values affected by these samples are identified in the annually cumulative bar graph (Figure 3.2-1) by a diagonal line on the top of the bar.

Shoreline Biomass:

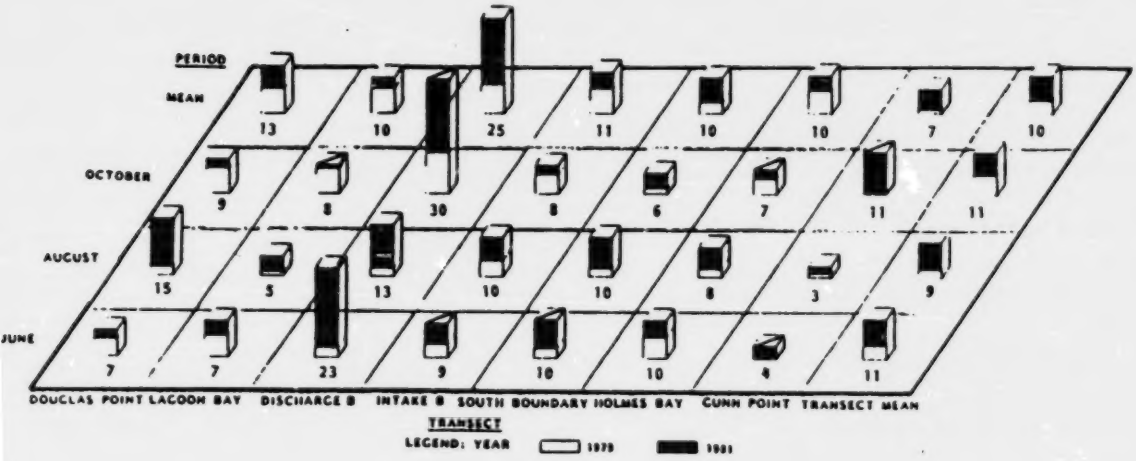
Shoreline samples showed similar seasonal trends for mean monthly biomass (Figure 3.2-1a). Highest biomass figures were observed in June and, except for Douglas Point, the lowest values were recorded in August. Overall yearly means were similar, although mean biomass for 1979 was somewhat higher than that recorded in 1981. Lagoon Bay and Bruce GS 'B' discharge samples were characterized by consistent high and low organic biomass determinations, respectively, in both years. Other high mean monthly values were recorded at Bruce GS 'B' intake and South Boundary (1979), and at Douglas and Gunn Pts (1981). The 1981 Gunn Pt values are questionable, however, due to the contamination of the sample with detritus.

Biomass at 3-m Depth:

Attached algal biomass in 1979 samples was generally greatest in October and least in June, whereas 1981 samples showed little variation among months (Figure 3.2-1b). Overall mean algal biomass was higher in 1981 than during 1979. Again, at least part of this difference is due to the large detrital component of the 1981 samples.



(a) ASH-FREE DRY WEIGHT OF SHORELINE ALGAE AT BRUCE B STATIONS



(b) ASH-FREE DRY WEIGHT OF ALGAE (3-M DEPTH) AT BRUCE B STATIONS

FIGURE 3.2-1

DISTRIBUTION OF ATTACHED ALGAL BIOMASS
AT BRUCE GS 'B' IN 1979 AND 1981

(Number represent mean organic content; g/m^2 per year)

Maximum seasonal mean biomass values recorded at the 3-m depths included the Bruce GS 'B' discharge location and the Douglas Pt discharge in both years, as well as Bruce GS 'B' intake (1979), and South Boundary (1981). Local seasonal mean minima were observed at Gunn Pt and South Boundary in 1979, and at Lagoon and Holmes Bay (1981).

Taxonomic composition, distribution and biomass of attached algae are of interest from several perspectives. The algae may act as a bioaccumulator of trace elements (OHRD Report 83-317-K), provide a habitat for benthic invertebrates, particularly oligochaetes (OHRD Report 82-107-K), be utilized, together with its attendant fauna, by gizzard shad (Bodola 1966) and have the potential for 'nuisance' growth leading to fouling of beaches by mats of detached decaying material (Taft 1975). Overall, the most prevalent alga at the Bruce GS 'B' site was the cold-water genus *Ulothrix*. *Cladophora*, the alga most often associated with nuisance growth, occurred infrequently, and was dominant in only one sample (Douglas Pt discharge shoreline, August 1983). At Bruce GS 'A', variable composition without widespread dominance by *Cladophora* was observed both in and away from the discharge area (OHRD Report 82-107-K). Due to the oligotrophic status of Lake Huron, biomass of algae is low in comparison to that observed in Long Point Bay Lake Erie, where 100 - 200 g/cm^2 was collected at shoreline locations throughout the spring and summer (OHRD Report 83-317-K).

3.2.4 Zoobenthos

Community Composition

Zoobenthos was sampled in early summer and in late fall during 1979 and 1981. Taxonomic composition of benthic fauna was relatively consistent at the order level between years (Table 3.2-6a). Oligochaetes and Diptera were the dominant orders, accounting for about 97% of all macroinvertebrates collected in either year. In 1979, Oligochaetes (66%) were more than twice as abundant as dipterans (chiefly chironomids; 32%). In 1981, the relative abundance of dipterans increased to 41%. Other individual invertebrate orders accounted for less than 2% of total zoobenthes abundance in either year.

Although benthic composition remained relatively stable at the order level between 1979 and 1981, differences in community composition between years were very noticeable at the generic and specific levels (Table 3.2-6b). However, taxonomic classification at the specific level is generally dependent upon characteristics which may not be visible in immature stages, a problem which is more likely to be encountered in late summer

TABLE 3.2-6

TAXONOMIC COMPOSITION OF ZOOBENTHOS AT BRUCE GS 'B' 1979 AND 1981

(a) Orders

Group	No. of Taxa		Mean Density - No./m^2		% of Total	
	1979	1981	1979	1981	1979	1981
Oligochaeta	9	11	540	659	65	56
Diptera	37	39	260	489	31	41
Acarina	1	1	10	22	1.3	1.8
Tricoptera	3	2	3	6	0.5	0.4
Ephemeroptera	1	3	1	5	0.1	0.4
Mollusca	7	4	14	3	1.8	0.3
Amphipoda	2	1	2	1	0.3	0.1
Total	60	61	830	1185		

(b) Major Individual Taxa

Taxon	Mean Density - No./m^2		% of Total	
	1979	1981	1979	1981
Nais pardalis	431	178	51	15
Nais simplex	1	331	<1	28
Nais variabilis	12	71	1	6
Nais spp	30	1	3	<1
Orthocladiinae	79	53	9	5
Cricotopus (cricotopus) cylandraceus	0	69	-	6
Parakiefferiella	17	25	2	2
Pseudosmittia spp	26	71	3	6
Paratanytarsus (microspecta)	15	41	1	4
Thiennemannimyia grp	38	29	4	2
Tubificidae	60	10	7	1

than in early fall. These immature individuals can often only be identified to generic (e.g. *Nais* spp) or sub-family level (e.g. Orthocladiinae), so that fewer taxa appear to be collected and the individuals are less evenly distributed among the list of taxa collected. Thus interpretation of taxonomic composition can be greatly affected by the timing of sampling. In addition, availability of taxonomic treatments at the specific level is continually increasing, allowing identification of previously unknown species.

Nais pardalis, the most common oligochaete collected in 1979, was much less abundant in 1981. Most specimens (approximately 94%) of this worm were collected in October of 1979, but in 1981 they were abundant only in the June - July samples (approximately 94%). *N. simplex* appeared to replace *N. pardalis* as the most common invertebrate in 1981, however, this may reflect taxonomic difficulties that exist between species of *Nais*. *N. simplex* is the most common invertebrate on exposed Georgian Bay shoals, with the exception of cladocerans (Barton and Carter 1982); this habitat is not dissimilar to the exposed littoral areas of Lake Huron in the region of Bruce GS 'B'. Both *N. simplex* and *N. pardalis*, are believed to be intolerant of organic enrichment, being most common in oligotrophic lakes (Learner *et al* 1978). The contribution of the naidids to total zoobenthes abundance remained relatively constant in the two years at about 65%.

Tubificidae, another family of oligochaetes, accounted for 7.3% of the macrobenthic fauna in 1979, but only 0.8% in 1981. These worms are often associated with organic enrichment and silt deposits, and their oxygen requirements are lower than those of naidids (Learner *et al* 1978, Barnes 1968).

Dipteran taxa in 1979 and 1981 were largely dominated by chironomids. Decreased density was found for unidentifiable (i.e. immature) Orthocladiinae in 1981. This may reflect the influence of the later sampling date in 1981 which allowed maturation of unidentifiable early instar larvae such as *Cricotopus [Cricotopus] cylandraceus* , which was common in 1981 (5.8%). The most abundant chironomid occurring in 1981 was also an orthoclad: *Pseudosmittia* spp., which is widespread in occurrence (Merrit and Cummins 1978). An overall increase in the abundance of the Orthocladiinae occurred between 1979 and 1981. This change was also apparent at the order level, where Diptera increased in density and community dominance from 31% in 1979 to 41% in 1981. Orthoclad chironomids are found over a wide range of environmental conditions (Merritt and Cummins 1978). Considerable differences in habitat requirements may be found between species within one genus (Saether 1979, Resh and Unsicker 1975). Comparisons of benthic communities between years are hampered by the inadequacy of information on

environmental requirements of specific taxa found at Bruce GS 'B'. In general, however, orthoclad chironomids are more often associated with unenriched, oligotrophic environments than are the Chironominae or Tanypodinae (Mason 1975).

Spring-summer macroinvertebrate diversity and richness were higher in 1981 than in 1979, while fall diversity was comparable between years, and richness somewhat higher in 1979 (Table 3.2-7). The decreased richness in 1981 fall samples may be due to nearshore storm disturbance and later collection dates compared to 1979. There were no consistent patterns in taxonomic richness or diversity in relation to depth of sampling; variability in these measures among depth was comparable to the variability observed among years (Table 3.2-7).

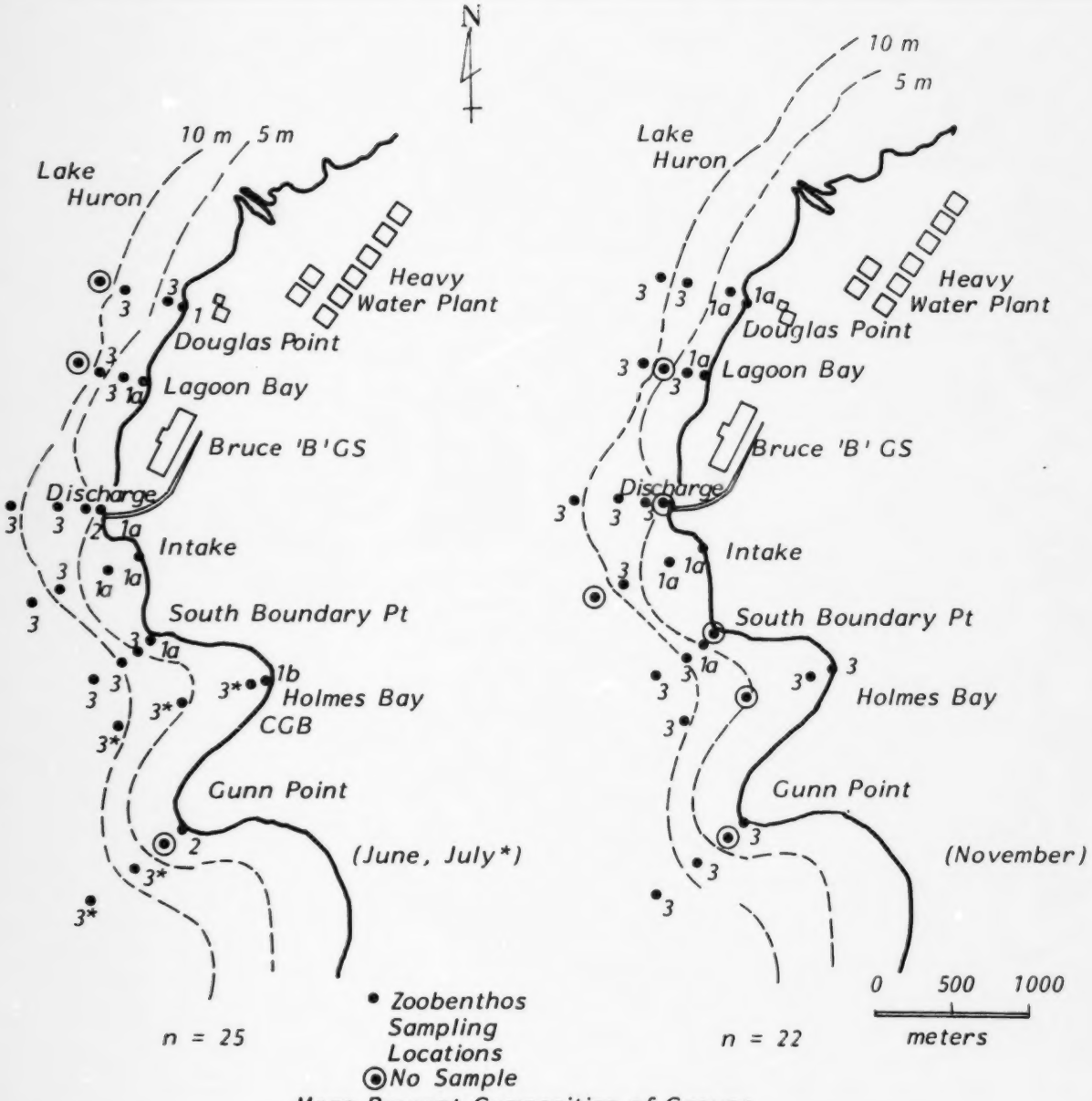
Douglas Pt and Lagoon Bay transects were characterized by relatively low mean diversities in both 1979 and 1981 and except for Douglas Pt in 1979 species richness was also relatively low. These neighbouring transects are at the northern extent of the Bruce GS 'B' study area, where the substrate composition is dominated by bedrock. This substrate is relatively homogeneous and does not usually support a diverse fauna. Highest mean diversity in both years was found along the Holmes Bay transect, where the size of the substrate ranges from silt to boulder and cobble. Taxonomic richness, however, was relatively low at Lagoon Bay in 1979 but high in 1981.

Zoobenthic assemblages identified by Mutual Information Analysis on the 1979 data indicated that the Naididae were the dominant component of all assemblages and the separation of faunal groups by habitat preference was therefore not possible (OHRD Report 83-182-K). In 1981, when chironomids formed a larger proportion of the total benthic fauna, Mutual Information Analysis resulted in the formation of four distinct assemblages (Figure 3.2-2). Assemblages, 1a and 3 represented 23% and 66%, respectively, of the 47 samples collected. *N. simplex* and *N. variabilis* dominated assemblage 1a while *Cricotopus [Cr.] cylandraceus*, a chironomid, was also common. This assemblage occurred mainly at the 1-m and 3-m depths in both the summer and fall collections. Assemblage 3 was dominated by common chironomid taxa (47.4%); oligochaetes represented only 13.6%. The 31 samples characterized by this assemblage generally occurred at deeper locations, particularly in June - July surveys. In October - November surveys, this assemblage was also found inshore (1-m, 3-m depths) at Holmes Bay and Gunn Pt, in the south of the study area. The other three assemblages (1, 1b, 2) were less common and represented a total of only five samples. All were dominated by various combinations of *Nais* species, and were always found in shallow water.

TABLE 3.2-7

COMPARATIVE TAXONOMIC RICHNESS AND DIVERSITY (H') OF ZOOBENTHOS AT BRUCE GS 'B' IN 1979 AND 1981

	1979		1981	
	Taxonomic Richness	Diversity	Taxonomic Richness	Diversity
(By Collection Date)				
June - July	4.1	1.61	8.7	2.35
Oct - Nov	8.0	1.97	6.6	2.00
(By Depth Contour)				
1 m	6.4	1.65	9.2	2.01
3 m	5.9	1.79	7.5	2.25
7 m	5.7	1.61	8.7	2.53
12 m	6.3	2.12	5.1	1.93
(By Transect)				
Douglas Point	7.4	1.76	5.9	1.80
Lagoon Bay	4.9	1.64	5.8	1.89
Bruce GS 'B' Discharge	5.7	1.45	7.9	2.32
Bruce GS 'B' Intake	6.5	1.98	7.2	2.22
South Boundary	6.7	1.74	7.7	2.28
Holmes Bay	5.7	2.05	10.8	2.46
Gunn Point	5.4	1.94	8.5	2.26
Total Mean	6.1	1.79	7.7	2.17



Mean Percent Composition of Groups

Taxa	1	1a	1b	2	3
Nais simplex	54.07	36.97	38.34	8.96	5.96
N. pardalis	28.49	9.11	2.08	64.73	5.58
N. variabilis	6.68	16.10	2.31	9.41	2.10
N. pseudoptusa	0.00	0.00	11.55	0.00	0.00
Pseudosmittia spp	0.00	3.94	0.00	0.00	12.99
Cricotopus (Cr) cylandraceus	0.00	10.98	4.85	2.01	12.15
Orthocladinae	0.29	0.27	2.77	1.74	7.37
Parakiefferiella spp.	0.00	0.00	0.46	0.27	7.74
Tanytarsus sp 2	0.29	1.03	0.69	3.47	7.17

FIGURE 3.2-2

DISTRIBUTION AND COMPOSITION OF ZOOBENTHIC GROUPS AT BRUCE GS 'B' IN 1981

Densities

The total number of organisms collected, as well as average density (No./m^2) was higher in 1981 than in 1979 (Table 3.2-8). Summer (June - July) benthic densities were 7.5 times higher in 1981, but fall densities (October - November) were 2.1 times greater in 1979 than in 1981. However, variation within seasons was considerable when all transects and depth contours were considered. Recruitment of invertebrates with seasonal life cycles generally occurs during the warmer months (Hynes 1970); sampling in 1981 was later on both occasions than in 1979, and the warm-weather recruitment may be a factor in the high June - July densities observed in 1981.

The later fall samples in 1981 may have decreased density due to occurrence of storms in late October. In the fall of 1981 densities at the 1-m depth were only 12% of the June -July densities for the same depth and year. Macroinvertebrate densities generally decreased with increasing depth, a pattern that was consistent in both seasons of both years (Table 3.2-8).

Among transects Holmes Bay had the lowest mean density of macroinvertebrates in 1979 (372/m^2) and the highest mean density in 1981 (2,353/m^2). Gunn Pt spars also had low mean densities in 1979 and large increases in 1981. Mean density decreased at the Bruce GS 'B' intake transect between 1979 and 1981 from 1,155 to 702/m^2. At Douglas Pt, which had the highest mean density of macroinvertebrates in 1979 (1,564/m^2), densities remained relatively high (1,764/m^2) in 1981. Substantial variation existed within transects which is likely to be partially related to changes in density patterns with depth and season. Also, these density distributions can in part be attributed to distributions of the Naididae. In 1981 lower overall densities in fall (November) samples, particularly in shallow waters, were largely due to low densities of *Nais* species. During other sample collections in 1979 and 1981, *N. pardalis* and other *Nais* species were relatively abundant at the 1-m and 3-m depths, which is similar to their occurrence in other waters (Barnes 1968, Brinkhurst 1978). *Nais pardalis* was most abundant at the Douglas Pt transect in 1979 and at both the Douglas Pt and Gunn Pt transects in 1981. *N. simplex* which was rare in 1979 was found in highest densities at the Douglas Pt. and Holmes Bay transects in 1981.

TABLE 3.2-8

COMPARATIVE MEAN ZOOBENTHIC DENSITIES
AT BRUCE GS 'B' IN 1979 AND 1981

	1979	1981
	No./m^2 Mean ± 1 S.D. (n)	No./m^2 Mean ± 1 S.D. (n)
(By Collection Date)		
June - July	225 ± 173 (28)	1697 ± 3194 (28)
Oct - Nov	1438 ± 1268 (28)	663 ± 792 (28)
(By Depth Contour)		
1 m	1364 ± 1669 (14)	2920 ± 4231 (14)
3 m	744 ± 700 (14)	805 ± 811 (14)
7 m	720 ± 991 (14)	741 ± 694 (14)
12 m	497 ± 527 (14)	254 ± 225 (14)
(By Transect)		
Douglas Point	1570 ± 1659 (8)	1728 ± 3642 (8)
Lagoon Bay	488 ± 499 (8)	565 ± 541 (8)
Bruce GS 'B' Discharge	992 ± 1450 (8)	755 ± 757 (8)
Bruce GS 'B' Intake	1155 ± 1409 (8)	701 ± 456 (8)
South Boundary	864 ± 781 (8)	789 ± 1106 (8)
Holmes Bay	372 ± 271 (8)	2399 ± 4601 (8)
Gunn Point	376 ± 312 (8)	1324 ± 2006 (8)
Overall Mean Density	831 ± 1085 (56)	1180 ± 2364 (56)

3.2.5 Fish

Community Composition

Adult and Juvenile Fish:

During the open water period (May to November) adult and juvenile fish were sampled by means of gill nets, trap nets and beach seines. The composition of the combined catches in those gear types are shown in Table 3.2-9. Over the three years more than 53 000 fish representing 54 species were captured. The largest overall catch was obtained in 1980, but the greatest number of species occurred in 1981. Thirty species were taken in all three years, and nine of these were at least moderately abundant, comprising 1% or more of the total catch. The most abundant were alewife (42%), spottail shiner (17%) and longnose sucker (10%). White sucker, yellow perch, lake chub, rainbow smelt and gizzard shad contributed 2 - 7% of the catch. With the exception of yellow perch and rainbow smelt, these are considered coarse or forage species. Round whitefish (1%) was the only moderately abundant salmonid species.

Nine game fish species were caught, although all but three were represented by fewer than 20 individuals. The most numerous were walleye (170), smallmouth bass (81) and rainbow trout (27).

The composition of the catch is shown by gear type in Table 3.2-10. The gill net catch was heavily dominated by alewife. This species was also co-dominant with spottail shiners in beach seines, and contributed to a significant portion of the trap net catch, which was dominated by suckers. Gill nets proved more effective than trap nets in sampling pelagic species. Of the species contributing to 1% or more of trap net catches, only smallmouth bass was not also among the major species in gill nets. However, this is due to the much larger total catch in gill nets, as almost half of the smallmouth bass caught were taken in gill nets. Beach seines, which sample a shallow inshore habitat, proved particularly effective in the capture of adult cyprinids and post-larval young-of-the-year of alewife and yellow perch. The greatest amount of variability among years occurred in beach seine catches. In particular, young-of-the-year yellow perch contributed significantly to the catch in 1980, but were taken rarely or not at all in the other two years.

During the months of December to April, adult and juvenile fish were sampled by gill nets only (Table 3.2-11). Gizzard shad dominated the overall catch, while alewife, longnose and white suckers, burbot and round whitefish were caught in moderate

TABLE 3.2.9

FISH SPECIES COMPOSITION IN ALL GEAR TYPES,
BRUCE GS 'B', MAY-NOVEMBER, 1979-1981

Species		No Caught				% Contribution			
Common Name and Family	Scientific Name	1979	1980	1981	Total	1979	1980	1981	Total
Lake sturgeon (Acipenseridae)	*Acipenser fulvescens*			1	1			<0.1	<0.1
Longnose gar (Lepisosteidae)	*Lepisosteus osseus*			3	3			<0.1	<0.1
Alewife (Clupeidae)	*Alosa pseudoharengus*	8 731	6 186	7 418	22 335	62.6	26.3	47.5	42.0
Gizzard shad	*Dorosoma cepedianum*	691	197	477	1 365	5.0	0.8	3.1	2.6
Pink salmon (Salmonidae)	*Oncorhychus gorbuscha*			1	1			<0.1	<0.1
Cisco	*Coregonus artedii*	3	3	46	12	<0.1	<0.1	<0.1	<0.1
Coho salmon	*Oncorhynchus kisutch*	5	2	2	9	<0.1	<0.1	<0.1	<0.1
Chinook salmon	*Oncorhynchus tshawytscha*	3	2	11	16	<0.1	<0.1	<0.1	<0.1
Round whitefish	*Prosopium cylandraceum*	196	195	323	714	1.4	0.8	2.1	1.3
Rainbow trout	*Salmo gairineri*	12	9	6	27	0.1	<0.1	<0.1	<0.1
Brown trout	*Salmo trutta*	2	1	1	4	<0.1	<0.1	<0.1	<0.1
Lake trout	*Salvelinus namaycush*		3		3		<0.1		<0.1
Splake	*S. namaycush* x *S. alpinus*	2	2	4	8	<0.1	<0.1	<0.1	<0.1
Rainbow smelt (Osmeridae)	*Osmerus mordax*	50	1 594	271	1 915	0.4	6.7	1.7	3.6
Northern pike (Esocidae)	*Exos lucius*	1		2	3	<0.1		<0.1	<0.1
Redbelly dace (Cyprinidae)	*Chrosomus eos*			1	1			<0.1	<0.1
Longnose dace	*Rhinichthys cataractae*	49	99	127	275	0.3	0.4	0.8	0.5
Lake chub	*Couesius plumbeus*	859	1 680	536	3 075	6.2	7.1	3.4	5.8
Creek chub	*Semotilus atromaculatus*		16		16		<0.1		<0.1
Carp	*Cyprinus carpio*	6	18	8	32	<0.1	<0.1	<0.1	<0.1
Golden shiner	*Notemigonus crysoleucas*			3	3			<0.1	<0.1
Emerald shiner	*Notropis atherinoides*	66	117	35	218	0.5	0.5	0.2	0.4
Common shiner	*Notropis cornutus*	46		1	47	0.3		<0.1	<0.1
Rosyface shiner	*Notropis rubellus*		1	2	3		<0.1	<0.1	<0.1
Spottail shiner	*Notropis hudsonius*	692	6 578	1 622	8 892	5.0	27.9	10.4	16.7
Mimic shiner	*Notropis volucellus*		1	7	8		<0.1	<0.1	<0.1
Bluntnose minnow	*Pimephales notatus*	10	24	28	62	0.1	0.1	0.2	0.1
Cyprinidae (unid.)			104	4	108		0.4	<0.1	0.2
Longnose sucker (Catostomidae)	*Catostomus catostomus*	1 072	2 174	2 302	5 548	7.7	9.3	13.2	10.4
White sucker	*Catostomus commersoni*	825	1 396	1 482	3 703	5.9	5.9	9.5	6.9
Golden redhorse	*Moxostoma erythrurum*		45	2	47		0.2	<0.1	<0.1
Shorthead redhorse	*Moxostoma macrolepidotum*			36	36			0.2	<0.1
Redhorse (unid.)		23	3		26	0.2	<0.1		<0.1
Brown bullhead (Ictaluridae)	*Ictalurus nebulosus*		3	1	4		<0.1	<0.1	<0.1
Channel catfish	*Ictalurus punctatus*	3	53	59	115	<0.1	0.2	0.4	0.2
Stone cat	*Noturus flavus*	4	6	2	12	<0.1	<0.1	<0.1	<0.1
Burbot (Gadidae)	*Lota lota*	50	73	129	252	0.4	0.3	0.8	0.5
Brook stickleback (Gasterosteidae)	*Culaea inconstans*			1	1			<0.1	<0.1
Threespine stickleback	*Gasterosteus aculeatus*			5	5			<0.1	<0.1
Ninespine stickleback	*Pungitius pungitius*	3	2		5	<0.1	<0.1		<0.1
Trout-perch (Percopsidae)	*Percopsis omiscomaycus*	61	61	3	124		0.3	<0.1	0.2
White bass (Percichthydae)	*Morone chrysops*	8	2	3	13	0.1	<0.1	<0.1	<0.1
Rock bass (Centrarchidae)	*Ambloplites rupestris*	1	6	11	18	<0.1	<0.1	<0.1	<0.1
Smallmouth bass	*Micropterus dolomieu*	13	38	30	81	0.1	0.2	0.2	0.2
Pumpkinseed	*Lepomis gibbosus*	1	1		1	<0.1	<0.1		<0.1
Black crappie	*Pomoxis nigromaculatus*		1		1		<0.1		<0.1
Fantail darter (Percidae)	*Etheostoma flabellare*			3	3			<0.1	<0.1
Johnny darter	*Etheostoma nigrum*			7	7			<0.1	<0.1
Yellow perch	*Perca flavescens*	498	2 768	548	3 814	3.6	11.7	3.5	7.2
Logperch	*Percina caprodes*	1	1	3	5	<0.1		<0.1	<0.1
Walleye	*Stizostedion vitreum*	19	77	74	170	0.1	0.3	0.5	0.3
Freshwater drum (Sciaenidae)	*Aplodinotus grunniens*	4	10	2	16	<0.1	<0.1	<0.1	<0.1
Mottled sculpin (Cottidae)	*Cottus bairdi*		3	5	8		<0.1	<0.1	<0.1
Slimy sculpin	*Cottus cognatus*	3	5	12	20	<0.1	<0.1	0.1	<0.1
TOTAL		14 013	23 560	15 660	53 233				
No. of Species (Excluding unid.)		35	42	48	54				

TABLE 3.2-10

FISH SPECIES COMPOSITION BY GEAR TYPE, BRUCE GS 'B'
MAY-NOVEMBER, 1979-1981 (SPECIES CONTRIBUTING 1% OR MORE TO CATCH)

Gear Type/ Species	No. Caught				% Contribution			
	1979	1980	1981	Total	1979	1980	1981	Total
Gill Nets								
Alewife	4 723	5 694	4 019	14 463	54.9	38.8	45.1	44.9
Longnose Sucker	907	1 726	1 535	4 168	10.5	11.8	17.2	13.0
Lake Chub	755	1 644	503	2 902	8.8	11.2	5.6	9.0
Yellow Perch	470	1 521	477	2 468	5.5	10.4	5.4	7.7
White Sucker	679	1 214	961	2 414	7.9	8.3	10.8	7.5
Rainbow Smelt	44	1 589	233	1 866	0.5	10.8	2.6	5.8
Gizzard Shad	689	196	412	1 297	8.0	1.3	4.6	4.0
Round Whitefish	193	195	317	705	2.2	1.3	3.6	2.2
All Species	8 603	14 664	8 916	32 183				
Trap Nets								
Longnose Sucker	164	448	767	1 379	31.4	53.8	47.8	46.7
White Sucker	139	182	521	842	26.8	21.8	32.5	28.5
Lake Chub	90	31	132	253	17.4	3.7	8.2	4.4
Alewife	77	85	55	217	14.9	10.2	3.4	7.3
Yellow Perch	28	44	59	131	5.4	5.3	3.7	8.6
Smallmouth Bass	6	19	24	49	1.2	2.2	1.5	1.7
All Species	518	832	1 603	2 953				
Beach Seines								
Spottail Shiner	692	6 135	1 560	8 387	14.3	76.1	29.8	46.2
Alewife	3 931	407	3 278	7 616	81.4	5.0	62.6	42.0
Yellow Perch	0	1 203	12	1 215	0	14.9	0.2	6.7
Longnose Dace	49	99	127	275	1.0	1.2	2.4	1.5
All Species	4 831	8 062	5 237	18 130				

TABLE 3.2-11

FISH SPECIES COMPOSITION IN WINTER GILL NET CATCHES (DECEMBER TO APRIL), BRUCE GS 'B', 1980 - 1983

	Total No. Caught				% Contribution			
	1981a March 31 - April 2	1980b* Dec 15	1983 Jan 28 - Feb 10	Total	1981a	1980b	1983	Total
Gizzard Shad	665	8	6	679	52.2	17.4	1.8	41.1
Longnose Sucker	176	4	58	238	13.8	8.7	17.3	14.4
White Sucker	101	5	96	202	7.9	10.9	28.7	12.2
Alewife	188			188	14.8			11.4
Burbot	28	11	116	155	2.2	23.9	34.5	9.4
Round Whitefish	49	11	30	90	3.8	23.9	9.0	5.4
Lake Chub	30	3	18	51	2.4	6.5	5.4	3.1
Yellow Perch	13		3	16	1.0		0.9	1.0
Coho Salmon	10			10	0.8			0.6
Rainbow Trout	5	2	1	8	0.4	4.3	0.3	0.5
Chinook Salmon	4			4	0.3			0.2
Spottail Shiner				4			1.2	0.2
Brown Trout	2			2	0.2			0.1
Rainbow Smelt	1		1	2	0.1		0.3	0.1
Walleye		1	1	2		2.2	0.3	0.1
Carp	1			1	0.1			<0.1
Lamprey			1	1			0.3	<0.1
Redhorse Sucker		1		1		2.2		<0.1
Total	1 273	46	331	1 650				

* Portion of round whitefish spawning study conducted on Bruce GS 'B' transects.

numbers. The majority of fish, including most gizzard shad and all alewife, were taken in the March-April, 1981 sampling period.

Taxonomic richness of the adult and juvenile fish community at the Bruce GS 'B' site was similar to that observed during the BNPD (Gunn Pt to Sand Bay) post-operational survey conducted during the same years (OHRD Report 84-47-K). At BNPD 41 to 48 species were collected. The larger number was taken in 1981, as was the case at Bruce GS 'B'. There was a general agreement in the major species between the sites. Principal differences were the greater importance of rainbow smelt, round whitefish and longnose dace at Bruce GS 'B' and the greater importance of bullhead, rock bass and bluntnose minnows at Bruce GS 'A'. These differences probably relate to the available habitat: Bruce GS 'B' is a relatively exposed site with steep gradient, and BNPD offers a greater proportion of shallow, protected areas, particularly in Baie du Dorl. Species-habitat relationships will be discussed further for major species.

Larval Fish:

Larval fish were sampled by tow nets during spring and early summer of each year. Over the four years, sixteen species were identified from the catches (Table 3.2-12). Only one species, deepwater sculpin, did not occur in the surveys of adult and juvenile fish. Rainbow smelt were the most abundant larvae collected (71% of total catch). Alewife (15.5) and burbot (8.0) were next in abundance. Rainbow smelt and burbot were caught in much greater proportion in larval tows than in netting for adults and juveniles.

Distribution and Abundance

Distribution of Adult and Juvenile Fish from Gill Nets:

The temporal and spatial variation in abundance of most adult fish was best described using catch-per-unit-effort in gill nets. For the 11 most common fish species, year, month, transect and depth differences in catch were examined. Statistical analyses were confined to a two-way analysis of variance which included the two factors (year and transect) thought to be most important in future assessment of station impact. The ANOVA was performed only on the seven major species which, as adults, would be effectively sampled by gill meshes 3.8 cm or greater. Results from 2.5 cm mesh and from McRae Pt were excluded since that gear and location were not fished in 1979.

The yearly mean catches of alewife, the most abundant species did not differ significantly, and were in fact rather constant

TABLE 3.2-12

SPECIES COMPOSITION OF LARVAL FISH TAKEN AT BRUCE GS 'B', 1979 TO 1982

Species	No Caught					% Contribution				
	May - August 1979	1980* May 23 - July 29	1981 May 14 - Aug 6	1982 April 29 - May 27	Total	1979	1980	1981	1982	Total
Rainbow Smelt	559	738	5 361	2 071	8 729	37.3	73.1	76.7	73.9	73.1
Alewife	840	191	869		1 900	56.0	18.8	12.3		15.5
Burbot	29	67	168	716	980	1.9	6.6	2.4	25.6	8.0
Johnny Darter	21		239		260	1.4		3.4		2.1
Unid. Cyprinids	7	10	239		256	0.5	1.0	3.4		2.1
Yellow Perch	22	2	19		43	1.5	0.2	0.3		0.3
Deepwater Sculpin	7		8	6	21	0.5		0.3	0.2	0.2
Slimy Sculpin	8		21		29	0.5		0.3		0.2
Unid. Sculpins		3		3	6		0.3	<0.1	0.1	<0.1
Troutperch	2		48		50	0.1		0.7		0.4
White Sucker			3	6	9			<0.1	0.2	<0.1
Logperch			1		1			<0.1		<0.1
Cisco			1		1			<0.1		<0.1
Round Whitefish			1		1			<0.1		<0.1
Unid. Coregonids	5				5	0.3				<0.1
Carp			2		2			0.1		<0.1
Freshwater Drum			1		1			0.1		<0.1
Spottail Shiner			3		3			<0.1		<0.1
Longnose Sucker				1	1				<0.1	<0.1
Total	1 500	1 011	6 984	2 803	12 298					

*1980 sampling restricted to Holmes and Inverhuron Bays

at approximately 34 fish/set (Table 3.2-13). Significant differences in yearly mean catch were found in the six other species, but year-to-year trends were not consistent among species. Three species, including yellow perch and both sucker species, were caught in significantly greater numbers in 1980. Catches of two species, gizzard shad and lake chub, were significantly greater in 1979, while round whitefish were caught in larger numbers in 1981. The greatest changes occurred in catches of gizzard shad and lake chub, both of which declined by a factor of 4 between 1979 and 1981.

Seasonal variation in catch-per-unit-effort of 11 major species in gill nets is shown in Figure 3.2-3. These data exclude McRae Pt, which was not sampled in 1979 open water sampling, nor in winter fishing. Peak catches of all species but one (burbot) occurred during the open water period (May to November). For most species the timing of peak catches was somewhat inconsistent among years, although broad seasonal trends were apparent. Species which were generally most abundant in spring (May, June) included alewife, longnose sucker, spottail shiner and lake chub. Since this group included the three most commonly caught species, spring was also the period with the highest overall gill net catch. One species, yellow perch, was most abundant in summer (July, August). Five species were most abundant in fall (September - November): gizzard shad, round whitefish, walleye, rainbow smelt and white sucker. In half of the species (alewife, longnose sucker, spottail shiner, lake chub, round whitefish, burbot) peak abundance approximated the reproductive season.

All fish species taken in appreciable numbers in gill nets (100 or more over the three years) were found on all six sampling transects. None were heavily concentrated (80% or more of catch) on one transect. The alongshore distributions of the seven major species common in 3.8 to 12.7-cm mesh gill nets are shown in Figure 3.2-4. Four species appeared to be more abundant in the southern transects: longnose and white sucker, yellow perch and lake chub. Gizzard shad were more frequently caught in the central-to-northern portion of the site. No trend was apparent in the alongshore distributions of alewife and round whitefish.

The only spatial trend found to be statistically significant (2-way ANOVA and SNK tests, McRae Pt excluded) was the occurrence of greater catches of yellow perch and white suckers along the southern transects. Catches of yellow perch at Holmes Bay (7.7 fish/set) were significantly greater than those from the Bruce GS 'B' intake transect to the Douglas Pt transect (3.1 - 3.9 fish/set). Similarly, significantly greater catches

TABLE 3.2-13

YEARLY MEAN CATCH-PER-UNIT EFFORT OF SEVEN MAJOR FISH SPECIES IN 3.8 TO 12.7cm MESH GILL NETS: RANKING AND STATISTICAL GROUPING

Species		Ranked Yearly Means		
		1	2	3
Alewife	Year	1979	1980	1981
	Mean CUE	37.5	35.4	29.0
	SNK Grouping*			
Longnose Sucker	Year	1980	1981	1979
	Mean CUE	11.4	8.3	6.5
	SNK Grouping			
White Sucker	Year	1980	1981	1979
	Mean CUE	6.8	5.5	4.8
	SNK Grouping			
Yellow Perch	Year	1980	1979	1981
	Mean CUE	7.7	3.4	2.7
	SNK Grouping			
Round Whitefish	Year	1981	1979	1980
	Mean CUE	2.1	1.4	1.2
	SNK Grouping			
Gizzard Shad	Year	1979	1980	1981
	Mean CUE	7.1	3.0	1.5
	SNK Grouping			
Lake Chub	Year	1979	1980	1981
	Mean CUE	5.5	2.1	1.2
	SNK Grouping			

* Based on 2-way ANOVA and Student-Neuman-Keuls Test. Means joined are not significantly different at 5% level.

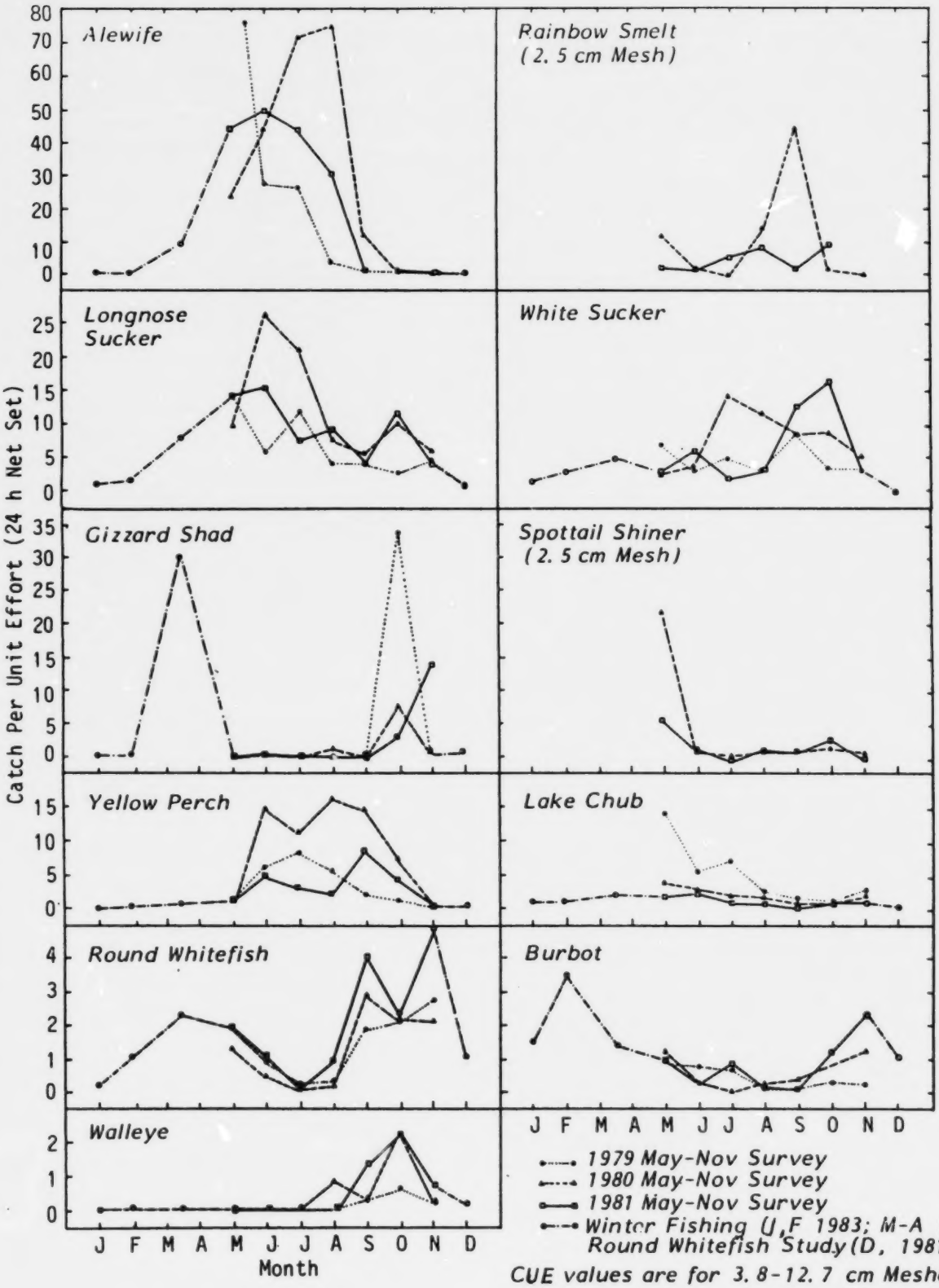
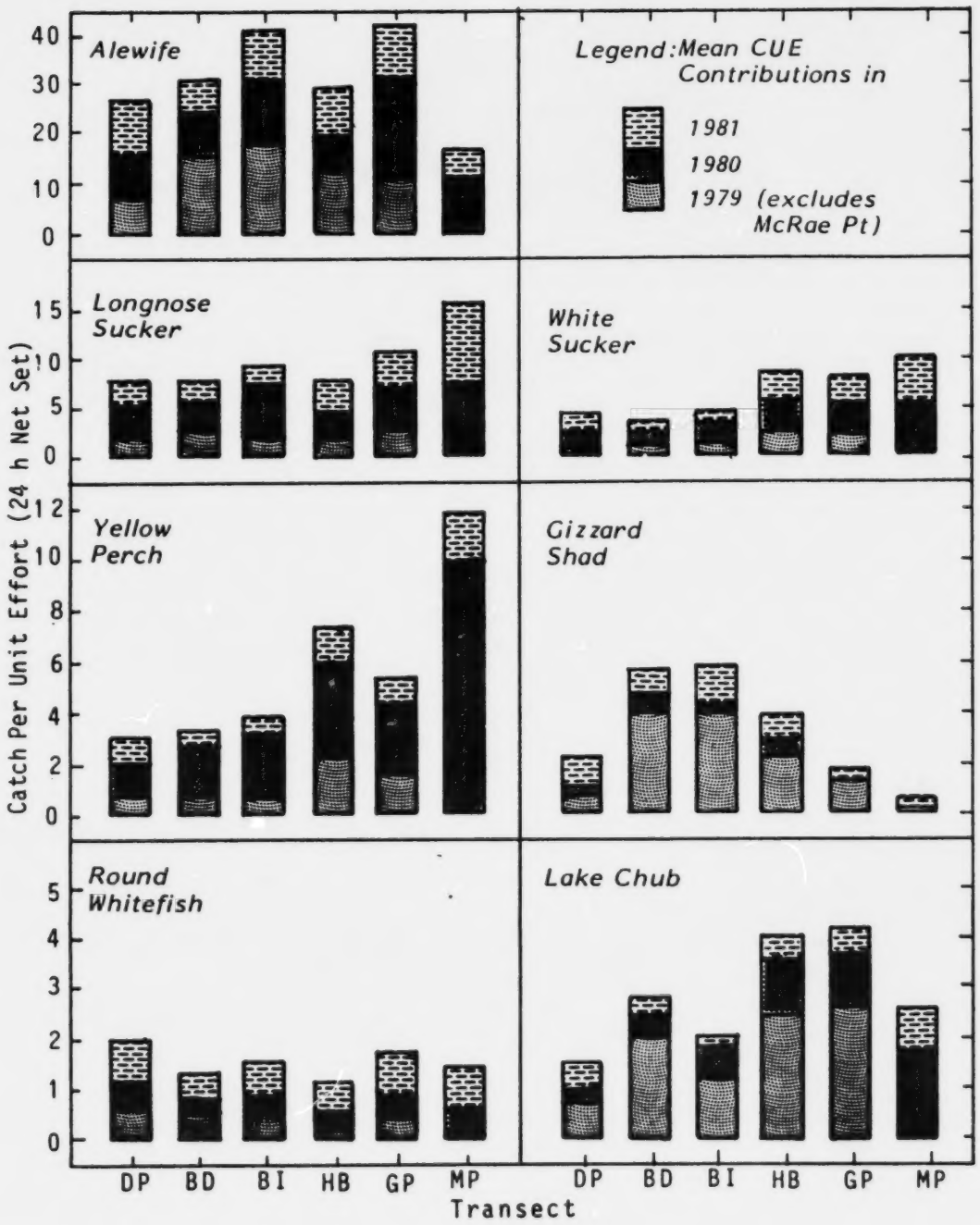


FIGURE 3.2-3

TEMPORAL VARIATION OF MAJOR FISH SPECIES IN GILL NET CATCHES, BRUCE GS 'B', MAY 1979 TO FEBRUARY 1983



Abbreviations: DP - Douglas Pt BD - Bruce 'B' Discharge
BI - Bruce 'B' Intake HB - Holmes Bay
GP - Gunn Pt MP - McRae Pt

FIGURE 3.2-4

ALONGSHORE DISTRIBUTION OF MAJOR SPECIES IN GILL NET CATCHES, BRUCE GS 'B', MAY - NOVEMBER, 1979 - 1981

of white sucker were obtained at Holmes Bay and Gunn Pt (8.0 - 8.2 fish/set) than at the three northern transects (3.5 - 4.7 fish/set).

Over the open-water period (May to November), seven of the 11 species discussed previously were caught in greater numbers in inshore (3 m) than in offshore (12 m) gill nets in all three years (Table 3.2-14). The contribution of inshore catches to the total catch-per-unit-effort was greatest for gizzard shad, spottail shiner and alewife. Two species, rainbow smelt and longnose sucker, were caught in greater numbers in the offshore (12 m) sets in 1980 only, while burbot were much more common in offshore sets in all three years.

The inshore-offshore distribution of several species varied seasonally. The most common trend, evidenced by longnose sucker, white sucker, lake chub and spottail shiner, was one of greater abundance inshore in spring, followed by greater offshore abundance during the fall, the transition occurring at some time in the summer. All of the above species are spring spawners, but in general they were found in relatively high numbers inshore long after the spawning season. In the case of round whitefish, which are fall spawners, the proportion of fish caught inshore increased from 40 - 60% in May - September to 72 - 93% in October-November. It was apparent that year-to-year variation in peak seasonal abundance for some species reflected the timing of sampling relative to inshore-offshore movements. In 1980 relatively high catches of alewife and longnose suckers, the two most abundant species, persisted later than usual into the summer (Figure 3.2-3). The majority of those fish (60% of alewife in August and 69% of longnose sucker in July) were caught in offshore nets. In other years alewife and suckers may have been abundant in the waters off Bruce GS 'B', but not at the depth contours (12 - 15 m) sampled by offshore nets. Evidence for this argument can also be obtained from acoustic fish census (below).

Winter gill netting comprised three periods: December, 1981; January-February, 1983; March-April, 1981 (Table 3.2-11). Species composition and spatial distribution in the December sampling period, which produced relatively few fish, were similar to January-February. The March-April sampling period, with a somewhat different species composition, appeared to be a time of transition.

Four fish species, longnose suckers, white suckers, burbot and round whitefish, were caught in appreciable numbers in early to mid-winter. Both sucker species tended to be more common on the southern-most transect (McRae Pt), as illustrated by January-February data (Figure 3.2-5). This trend was similar to

TABLE 3.2-14

INSHORE-OFFSHORE DISTRIBUTION OF MAJOR FISH SPECIES AT BRUCE GS 'B', 1979 - 1981 (GILL NET CATCH-PER-UNIT-EFFORT)

Species	1979 May-Nov		1980 May-Nov		1981 March-Apr		1981 May-Nov	
	3 m	12 m	3 m	12 m	3 m	12 m	3 m	12 m
Alewife	44.3	3.8	41.4	24.3	7.3	9.5	37.0	14.9
Longnose Sucker	7.3	5.7	9.1	10.9	12.6	4.3	11.8	7.9
White Sucker	6.8	3.0	8.6	6.2	7.6	1.5	6.7	5.5
Lake Chub	6.5	4.4	11.3*	4.7	2.0	0.8	18.3*	2.5
Yellow Perch	3.9	2.9	10.2	8.9			2.4	3.5
Gizzard Shad	9.9	4.8	2.2	0.3	63.8	2.3	4.5	1.0
Round Whitefish	1.7	1.1	1.6	0.9	3.7	0.8	3.1	1.0
Rainbow Smelt			11.8*	13.1			10.4*	2.6
Spottail Shiner			5.9*	1.0			2.6*	0.9
Burbot	0.1	0.7	0.1	0.7	1.0	1.5	0.4	1.3
Walleye			0.8	0.2			0.7	0.2

* 2.5-cm mesh only; all others 3.8 to 12.7-cm mesh

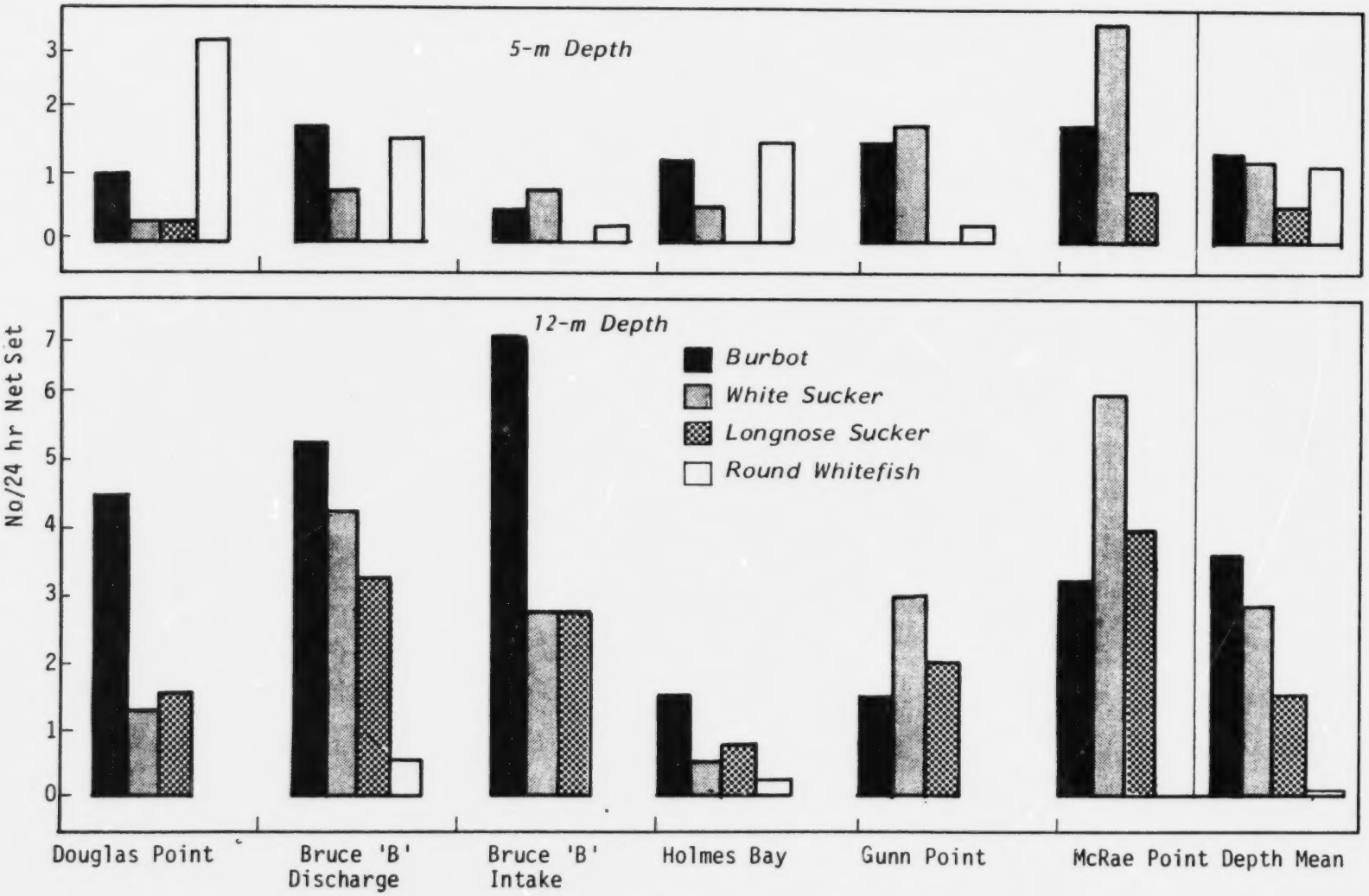


FIGURE 3.2-5

SPATIAL DISTRIBUTION OF GILL NET CATCH-PER-UNIT-EFFORT,
BRUCE GS 'B', JANUARY - FEBRUARY, 1983

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167194-RD

that observed in the late winter (March-April) and open water periods (May - November, Figure 3.2-4). Round whitefish appeared to be concentrated in the northern half of the site in January-February, but not in the other winter sampling periods (Figure 3.2-5), nor during the open water period. There was no evidence of attraction of round whitefish to waters of elevated temperatures, as relatively high catches were made both in the presence and absence of discharge plume intrusions at the sampling locations (OHRD Report 83-507-K). Burbot were also more abundant on the northern transects in January-February, 1983. In late winter, 1981 more were caught off McRae Pt and Gunn Pt, but the numbers were too small to suggest a trend.

Alongshore distribution of the two clupeid species, gizzard shad and alewife, in late winter (March, April) did not suggest areas of concentration within the Bruce GS 'B' study area. However, a notable feature in the winter distribution of these two species, and of longnose suckers, white suckers, burbot and round whitefish, was low abundance in Holmes Bay. This depression in catch was consistent among winter sampling periods but contrasted with open-water results, when catches at Holmes Bay were generally intermediate among locations. A possible ecological explanation is that a more suitable range of physical environmental conditions is associated with points of land than with embayments in winter, but this cannot be substantiated with data presently available.

In mid-winter three of the four common species, burbot, longnose sucker and white sucker, were considerably more common in offshore (12 m) gill net sets, the exception being round whitefish, almost all of which were caught inshore. By late winter (March-April, 1981) most species had become more abundant inshore (3 m contour), the exception being alewife, which were caught offshore in slightly larger numbers (Table 3.2-14). During this transition period some major fish species had retained their early to mid-winter depth distribution (whitefish, burbot), while others had assumed their spring distribution (suckers, gizzard shad) or appeared to be moving towards it (alewife).

Distribution of Adult and Juvenile Fish from Trap Nets:

Trap net catches supplemented gill net data during the open water period by sampling fish moving alongshore at the 2 to 3-m depth. Only five species were sufficiently common in trap nets to allow examination of trends: longnose sucker, white sucker, lake chub, alewife and yellow perch.

Among years, catches of both sucker species were highest in 1981 (Table 3.2-15), alewife and lake chub were taken in greatest

TABLE 3.2-15

DISTRIBUTION OF MAJOR FISH SPECIES IN TRAP NETS: CATCH-PER-UNIT-EFFORT

Species	Douglas Pt			Bruce GS 'B' Discharge			Holmes Bay		
	1979	1980	1981	1979	1980	1981	1979	1980	1981
Longnose Sucker	1.0	3.4	3.1	5.5	6.8	4.5	0.3	4.9	4.6
White Sucker	0.8	0.5	1.7	5.5	1.8	3.4	1.6	1.7	4.9
Lake Chub	0.2	0.1	0	2.6	0.1	1.8	0.2	0.9	3.9
Alewife	0.3	4.8	1.9	0	0.1	0.4	2.7	0.7	0.6
Yellow Perch	0	0	0.2	0.5	0.5	0.1	0.4	0.1	1.1
Species	Gunn Pt			McRae Pt			Overall		
	1979	1980	1981	1979	1980	1981	1979	1980	1981
Longnose Sucker	4.9	5.8	9.4	-	8.4	15.5	2.9	5.2	7.7
White Sucker	2.1	6.4	9.7	-	1.8	5.0	2.5	2.1	5.2
Lake Chub	3.4	0.6	0.1	-	0.2	0.5	1.6	0.4	1.3
Alewife	2.5	0	0.1	-	0.3	0.1	1.4	1.0	0.5
Yellow Perch	1.2	2.1	1.2	-	0.4	0.7	0.5	0.5	0.6

numbers in 1979, while catches of yellow perch remained at approximately the same level in all years. Among-year variation was similar to that observed in trap nets and shallow (3 m) gill nets at BNPD (OHRD Report 84-47-K). In the case of suckers and yellow perch, among-year variation in trap nets differed from that observed in gill nets at Bruce GS 'B' (3 m and 12 m), where catches of all three species were considerably greater in 1980.

Although trap nets sampled a relatively shallow inshore environment, seasonal peak catches consistently occurred during the spawning period only for lake chub. Peak catches of both sucker species and alewife occurred one or two months after the spawning period in some years. Of these three, white sucker appeared to be the most persistent in shallow water. Yellow perch catches in trap nets, like those in gill nets, bore no relationship to the spawning period.

Examination of transect mean catch-per-unit-effort suggested alongshore distributions similar to those observed in gill nets. Variability among transects/year cells was high, particularly for pelagic species (alewife) and pelagic-demersal species (lake chub and yellow perch), for which trap netting is a relatively inefficient capture method.

Distribution of Adult and Juvenile Fish from Beach Seines:

Beach seines were used to sample small fish in the shallow onshore environment (0 to 2-m depth). Adult and juvenile fish sampled by beach seines at Bruce GS 'B' (Table 3.2-10) included adults present during their spawning period in spring (spottail shiner) and adults and juveniles of species normally resident on exposed shorelines (longnose dace). Juveniles of large species such as gizzard shad and sucker were caught infrequently. Catches of adult spottail shiners in spring were variable, with no obvious trends apparent, but there was evidence of concentration of shiners on the Douglas Pt transect in the fall. Douglas Pt was also the only location where significant catches of juvenile gizzard shad were made (1981 only). Adult and juvenile longnose dace were moderately abundant in 1980 and 1981 (1.7 fish/haul) but low in 1979 (0.3 fish/haul). Their abundance generally peaked in June and July, and most were caught in the southern part of the site, particularly Holmes Bay. The majority of the fish taken in beach seines from July on were age 0+ fish (shiners, alewife, yellow perch).

Acoustic Determination of Fish Distribution and Abundance:

This technique was intended to complement netting by providing one-point-in-time determinations of relative abundance of adult and juvenile fish through the water column over a large area.

The depths sampled acoustically (5 - 35 m) extended well beyond the offshore (12 - 15 m) gill net sets, and included the Bruce GS 'B' intake (Figure 2.1-1). This was the only technique used which allowed correlation of pelagic fish distribution with thermal structure. Species composition of fish echoes was not known directly, but was inferred from characteristic patterns of echo aggregation and associated gill net catches.

Fish density estimates were derived for the entire acoustic grid in 1979, and for selected portions of transects to either side of the Bruce GS 'B' intake in 1981 (Table 3.2-16). In 1979, mean density estimates over the entire grid were relatively constant over a wide temporal range - much more constant than gill net catches in the corresponding months. Comparison of mean densities in 1979 and 1981 for the selected segments (235 versus 204 fish/Ha at 21-25 m and 678 versus 756/Ha at 11 to 15 m) suggested that fish abundance in the nearshore area did not change appreciably. The range in observed density in the vicinity of the intake (11-15 m) could be used to indicate the potential for fish entrapment. This also changed only slightly between years, from 317 to 1041 fish/Ha in 1979 to 232 to 1253 fish/Ha in 1981. Qualitative evaluation of echograms from all three years also did not suggest appreciable year-to-year changes in abundance.

Within years, summer (July to early September) was typically a period of relatively high fish abundance within the acoustic grid. Estimated densities near the intake ranged from approximately 500 to 1200 fish/Ha, and extensive schools of pelagic fish, likely alewife, were observed by day within the 25-m contour. Fish abundance in the fall samples differed appreciably among years, being relatively low in 1980 and 1981, but slightly higher than summer densities in 1979. In 1980 and 1981 fish concentrations in fall were restricted to the offshore portions of the grid, beyond the 25-m depth, while in 1979 considerable aggregation of fish was observed in inshore waters. The latter was primarily attributed to larger fish such as suckers and round whitefish. Numbers of fish observed acoustically were often relatively lower in spring, particularly in night samples. This contrasted with high spring catches in 3-m gill nets. Since gill nets are inshore of the acoustic grid, movement of fish into shallow water was considered the primary reason for the low acoustically estimated densities in spring.

In general, most fish echoes were observed near the bottom. However in night samples and some day samples there was also a sizable midwater component which was not sampled by netting. In most acoustic samples fish were distributed across isotherms intersecting the bottom, so that their distribution within the

TABLE 3.2-16

ACOUSTICALLY ESTIMATED FISH DENSITIES (MEAN NO/HECTARE)
IN THE VICINITY OF BRUCE GS 'B' DURING 1979 AND 1981

Month	Time of Day	Yr	Entire Grid	Two Transects Nearest Intake		
				All Depths	21-25 m	11-15 m
June	Day	79	243	190	130	317
		81	-	-	77	1007
	Night	79	417	397	591	533
		81	-	-	85	232
July	Day	81	-	-	383	1020
	Night	81	-	-	175	576
Aug/Sept	Day	79	483	534	49	478
		81	-	-	383	1253
Oct/Nov	Day	79	496	581	227	1019
		81	-	0	120	451
	Night	79	512	561	179	1041
Segment Means		79			235	678
		81			204	756

nearshore area did not appear to be related to thermal gradients. However, in two late summer samples (Aug 30, 1979 and September 3, 1981), when marked stratification was present beyond the 12 m depth, the majority of fish echoes were observed between 10 and 18°C.

Distribution of Larval and Postlarval Age 0 Fish from Tow Nets:

Among-year comparisons for numbers of larval fish caught were made by examining temporal peak densities in shallow surface tows from the 1 to 1.5 and 3-m depth contours (Table 2.3-1). Peak abundance of rainbow smelt and burbot larvae in inshore surface waters appeared to occur within the sampling period in all four years (1979 to 1982). Highest densities of rainbow smelt larvae occurred in 1981. Highest densities of burbot larvae occurred in 1982, but densities determined from limited sampling in 1980 were also relatively high. Sampling did not extend to the period of alewife emergence in 1982, while among the remaining years highest densities were observed in 1980 when sampling was restricted to two embayments (Holmes and Inverhuron Bays). Examination of adult and juvenile catch records for all three species over the commissioning and postoperational period may show whether the observed among-year differences are reflected in subsequent year class strength.

Seasonal peaks in abundance of the more commonly caught species always occurred on the sampling dates immediately following peaks of emergence (hatching), judging by the size of larvae taken. Rainbow smelt was the principal species with an early spring peak in abundance; yellow perch and burbot generally peaked in late spring, while alewife peaked in mid-summer. More detailed discussion of early life history will be presented later for individual species.

In two years, 1979 and 1981, spatial variation in abundance of larval fish was assessed in alongshore, inshore-offshore and vertical dimensions. Spatial resolution in 1980 (two locations) and 1982 (eight locations) was restricted to alongshore variation in shallow (1-1.5 m) waters. Inshore-offshore distribution in surface waters differed in 1979 and 1981; mean catches of both rainbow smelt and alewife were similar at the 3 and 7-m contours in 1979, but were substantially lower at the 7-m contour in 1981.

In 1979 a shift from initially greater abundance of both species offshore to greater abundance inshore led to an inference of shoreward migration of alewife and smelt larvae (OHRD Report 83-182-K). However, no such shift was observed in 1981, when both species were initially most abundant in inshore waters. Since other data from Lake Huron (OHRD Report 84-47-K)

and Lake Ontario (OHRD Report 80-69-K) also indicate that larvae of these two pelagic species are initially concentrated inshore, high abundance offshore in 1979 can be attributed to offshore displacement of early-emerged larvae by mass water movements. Upwellings, alongshore currents sweeping past points of land, and plume entrainment can all result in passive offshore displacement of fish larvae in surface waters. While alewife tended to remain in nearshore waters as they developed, two species, rainbow smelt and burbot, moved to offshore bottom waters. The latter trend was more clearly defined for smelt.

Relatively rapid passive displacement of larvae by alongshore currents makes it difficult to identify spawning or nursery areas of the major species. For example, at a mean alongshore current velocity of 8 cm/s (mean current velocity 0.6 km off Bruce GS 'B' during May-Sept, 1977-1979 ranged from 8 to 13 cm/s; Ont Hydro Hyd Studies Dev Dept Report 82393), fish larvae could be displaced passively from Lagoon Bay to Gunn Pt, a distance of 7 km, in 24 h. Among the three common species there was a general tendency for the highest overall densities to occur in the southernmost locations, Gunn Pt and Inverhuron Bay. However, initial concentrations of rainbow smelt larvae in 1979 and 1982, and alewife larvae in 1979 and 1981, occurred at northern sampling locations. In subsequent sampling the larvae of these two species had increased in total length and were most abundant at the southernmost locations. The data therefore suggests that a large proportion of these larvae may have originated in the northern portion of the sample area, or possible still futher north. Concentration of alewife and smelt spawning along the shoreline in the vicinity of Bruce GS 'A' just north of the Bruce GS "B" site has been suggested by BNPD postoperational data (OHRD Report 84-47-K). It is thus possible that the presence of the Bruce GS 'B' discharge plume may alter the distribution and abundance of the more common larval species by interference with alongshore drift.

Inshore Distribution of Postlarval Age 0 Fish from Beach Seines:

Among the common fish species at the Bruce GS 'B' site, alewife, spottail shiner and yellow perch were taken in beach seines as postlarval age 0 fish (young-of-the-year) in significant numbers in at least one year. Beach seine catches of all three species peaked in late August or September. In the case of alewife and spottail shiners, which tended to remain near shore during their larval-postlarval period, this represented a lag of approximately four weeks from late peaks in tow net catches. In the case of yellow perch, which have a pelagic larval phase, this lag was 7-10 weeks. Rainbow smelt and burbot were common in larval tow nets but rare in beach seines, having dispersed offshore as postlarvae.

In general, peak catches of age 0 fish in beach seines occurred in the southern portion of the study area, near locations where late peaks in larval densities were obtained. Holmes Bay and the adjacent location, Gunn Pt produced relatively large catches of all three species in one or more years. McRae Pt, which was seined only in 1981, produced the largest catches of alewife in that year. Although Inverhuron Bay was not sampled by beach seine it may also be an important area for age 0 fish, as it is bounded by the productive Gunn Pt and McRae Pt locations and had moderately high densities of several larval species in inshore tow net sampling conducted in 1980 and 1982. North of Holmes Bay, the Bruce GS 'B' discharge location produced relatively high catches of spottail shiners in two years.

Ecology and Biology of Major Fish Species

Alewife *(Alosa pseudoharengus):*

This pelagic clupeid was the most abundant fish species at the site, contributing 42% of the catch in May-November survey netting in all gear types, and 15% of the catch in larval fish tows. Alewife also appeared to be responsible for the bulk of acoustically estimated fish densities at depths of 5 to 35 m. While not of commercial or recreational value, alewife are considered the primary forage fish for large salmonid species which are important in the sport fishery (Argyle 1982). As consumers they may also exert an important influence on nearshore trophic relationships, altering crustacean zooplankton community composition and population parameters (e.g. Drenner *et al* 1982). Due to its numbers, this species also has the potential to interfere with station operation through major impingement.

Inshore abundance of alewife in the Great Lakes near generating stations has been linked to their spawning migration (Graham 1956), with spawning itself occurring from May to July depending on the temperature regime (Scott and Crossman 1973). However, gill netting and acoustic observations indicate that this species has occurred in the nearshore waters of Bruce GS 'B' in substantial numbers from late March until at least September and possibly as late as November. In addition peak abundance, as shown by gill net catches, was inconsistent in timing, occurring in a different month in each year (May 1979; August 1980; June 1981; Figure 3.2-3). At BNPD locations north of the Bruce GS 'B' site (BHWP discharge to Sand Bay) the peak alewife catch in 1979 also occurred in May, while peak catches in 1980 and 1981 occurred in June and May, respectively. The earlier peaks in the same years at BNPD can be attributed at least in part to the absence of 12-m gill net sampling and the relatively shallow nearshore topography.

Alewife were distributed relatively evenly along the shoreline of the study area. Their depth distribution, as indicated by gill netting and acoustic census, varied seasonally and diurnally. In late winter (March-April, 1981), when alewife first appeared in gill net catches the majority were found at 12 m. In spring (May-June) alewife were generally 2-3 times as common at 3 m as at 12 m. Acoustic census indicated that inshore movement occurred at night, and trap net catches (both at Bruce GS 'B' and BNPD) indicated that in several cases large numbers of alewife moved through depths of less than 3 m at this time. Similar movements were suggested by acoustic census and associated gill netting in spring along the north shore of Lake Ontario (OHRD Report 80-197-K). In summer (July-early September) the distribution of alewife appeared to shift to one of moderate depths. When high catches of alewife were obtained in summer (1980 only), the majority of fish were taken in the 12-m sets. In addition fish aggregations observed acoustically in summer were attributed to alewife which were most prevalent at depths greater than 10 m. Acoustic observations of a broad distribution of alewife across thermal gradients were, in most cases, in agreement with previous observations in the vicinity of Douglas Pt (Minns *et al* 1978) and along the north shore of Lake Ontario (OHRD Report 80-197-K). There appears to be no consistent correlation between alewife distribution and lake thermal structure. However, alewife did tend to be relatively uncommon at temperatures more than 2°C above their reported summer preferendum of 16°C (Otto *et al* 1976).

Most alewife spawning took place from mid-June (1981) to late July (1979, 1980), based on catches of larvae and assuming a one week incubation period (Scott and Crossman 1973). Differences in timing of larval occurrence among years were evidently due to temperature. June water temperatures were on average 4°C lower in the first two years than in 1981 (Figure 3.1-5) which probably delayed alewife spawning. In 1981 inshore abundance of alewife was interrupted by a major upwelling in late July. Subsequently a second group of recently emerged larvae appeared in early August, which occurred together with a much larger group of larvae that were in a later stage of development. Thus alewife spawning in 1981 was split into two periods as a result of the upwelling. Similar influences of upwellings on alewife spawning and inshore abundance of larval alewife were reported for Lake Michigan by Heufelder *et al* (1982).

Measurements of alewife larvae caught in tow nets indicated rapid early growth with lengths of 15 mm and 19 mm being attained by August in 1979 and in 1981, respectively. Alewife larvae tended to remain in inshore waters as they developed, becoming vulnerable to capture by beach seines in August or September. Although no further length information was obtained

at Bruce GS 'B' or BNPD, casual observations suggested that growth was not dissimilar from Lake Ontario, where alewife reached a length of approximately 30 mm in their first year and matured at approximately 160 mm (OHRD Report 81-221-K).

Rainbow smelt *(Osmerus mordax)*:

Larval tow catches were heavily dominated by rainbow smelt (71%) although this species comprised only 3.6% of the catch in routine survey netting. Smelt are quite abundant in offshore waters of Lake Huron, where their biomass may be greater than that of alewife in some years (Argyle 1982). Although smelt support a sizable commercial fishery in Lake Erie, landings in Lake Huron have been insignificant (Ont. Min. Nat. Res. Publ. 1981), and their principal value in Lake Huron is as forage for sport fishes.

Due to their small size (adults 12-16 cm) and slender body shape rainbow smelt were only captured effectively by 2.5 cm (1") mesh gill nets, which were not used in 1979 and missing from a large proportion of sets in 1981. In 1980 peaks in catch occurred in May and September. The May peak consisted almost entirely of smelt captured at a depth of 3 m at Douglas Pt, while catches on all six transects, principally at 12 m, contributed to the larger September peak. Acoustic census revealed dense near-bottom layers and clusters of fish echoes, typically associated with smelt, in offshore areas (15-35 m) in all three years. Inshore abundance of smelt in spring was probably associated with the spawning migration. A fall peak in inshore abundance of smelt was also seen at Nanticoke on Lake Erie (OHRD Report 82-59-K). Since the diet of adult and subadult smelt includes fish, their presence in the nearshore area in significant numbers could be of some importance in terms of survival and year class strength of age 0 fishes.

Larval smelt were at peak density in mid-May (1981) to late May (1979, 1980, 1982). In 1982, when sampling began in late April, only eggs were present initially, with larvae appearing in mid-May. Assuming egg incubation at ambient temperatures of approximately 6°C, most smelt spawning took place from early to late April (OHRD Report 78-343-K). Poor catches of adult smelt in May suggested that most spawners moved offshore within 2-3 weeks. Results of early work at BNPD (OHRD Report 80-45-K) suggest the possibility that a second peak in spawning may occur in May of some years, but this cannot be confirmed due to the lack of larval measurements from those collections.

Smelt larvae dispersed from nearshore surface waters to deeper offshore strata by the time total length exceeded 7 mm (1981 and 1982 data). By July 7, 1981, the mean length of smelt larvae taken in bottom samples had reached 14 mm. Similar rapid offshore dispersal of smelt larvae from inshore surface waters was observed in Lake Ontario (OHRD Report 80-69-K).

Round Whitefish *(Prosopium cyclindraceum):*

This was by far the most abundant salmonid species taken at Bruce GS 'B', contributing 1.3% of the May-November catch in all gear types. In all sampling, including winter sampling and additional sampling conducted to assess round whitefish spawning (1980, 1981), 900 round whitefish were collected. This includes 96 fish not reported in catch statistics given in Tables 3.2-9 and 3.2-11: 37 taken in gill nets left in the water for 5-7 days in December 1980 and 59 taken at locations north of Douglas Pt in November-December, 1981. Commercial landings of lake whitefish for Lake Huron have far exceeded those of round whitefish (Ont. Min. Nat. Res. Publ. 1981), but no lake whitefish were taken during the Bruce GS 'B' survey and they have been rare or absent in other studies conducted at BNPD. This discrepancy may be due to several factors, including differences in distribution of the two species, lower commercial value of the smaller round whitefish, mesh size restriction, and reporting of mixed commercial catches as lake whitefish only. Round whitefish do not appear to be sought by anglers in Ontario (Scott and Crossman 1973).

Although some round whitefish were taken in gill nets set at 3 and 12 m throughout the year, catches varied in a consistent seasonal pattern, with peaks in March-May and September-November. Highest catch-per-unit-effort in gill nets was observed in November, 1981 (5 fish/set). From May to September 40% or more of the round whitefish were taken in deep (12 m) sets, but in October, as the spawning period approached, most were taken in shallow (3 m) sets, where they continued to be more common through the winter. There was also some evidence of seasonal variation in alongshore distribution. Prior to and during the spawning period (Oct-Nov) the distribution of whitefish was relatively even along the shoreline in all three years, and in 1981 catches north and south of Douglas Pt were similar (12-32 from BHWP to Scott Point, and 16-25 from Douglas Pt to McRae Pt). However, at other times consistently larger catches were obtained at Douglas Pt. There is no evidence linking these larger catches to elevation of water temperatures by discharge plumes. Attraction to heated water can be discounted for the winter of 1983 and the majority of cases in May-September since the largest catches were associated with ambient lake temperatures or were taken from the 12-m depth below the influence of buoyant plumes.

Round whitefish was the only species in which reproductive status was examined (1980 and 1981) to allow assessment of the distribution of spawners and the timing of spawning at the site. In 1980 both ripe (6) and post-spawn (8) fish were collected only in late November. In late November, 1981, 39% of 150 fish examined were ripe, while 9% were in post-spawn condition; three weeks later (Dec 15) 93% of 28 fish were in post-spawn condition. These observations indicated that most spawning occurred in late November-early December in both years and that it occurred in or very near the Bruce 'B' study area. Ambient nearshore temperatures in late November in both years were 5 to 7°C, slightly higher than the 2 to 4°C suggested for the north shore of Lake Ontario (Haymes and Kolenosky 1984).

While the simultaneous occurrence of both ripe and post-spawn fish in both years suggests that spawning was occurring within or very near the Bruce GS 'B'/BNPD study area, no inferences can yet be made concerning discrete spawning areas. In 1980 all ripe and post-spawn fish were caught on the southernmost transects, but in 1981 such fish were distributed along the entire study area. Gravel-cobble and cobble-boulder substrates, which are probably preferred for egg deposition (Haymes and Kolenosky 1984), occurred in varying amounts along most transects.

Larval fish sampling over the four years at Bruce GS 'B' produced only 7 round whitefish larvae (including the unidentified coregonid larvae from 1979), this despite the inclusion of early (April) sampling in 1982 aimed specifically at the larvae of fall spawners. In BNPD sampling an additional 13 unidentified coregonid larvae, possibly round whitefish, were collected. These numbers were too small to make meaningful inferences concerning the source or distribution of age 0 round whitefish. The low numbers of round whitefish larvae may be related to poor spawning success, a lack of susceptibility to the larval fish sampling method or to the rapid dispersal of newly hatched larvae from the nearshore area. Inappropriate sampling method was the more probable cause since, in recent work in Lake Ontario using a benthic sled, round whitefish larvae were found in cobble substrates at the 3 to 7-m depth (OHRD Report 82-539-K). Similarly, very few juvenile round whitefish have been collected; since these fish should have been susceptible to the smaller-mesh gill nets if they occurred in the nearshore area, it appears that they migrated beyond the 15-m contour, or to areas north or south of BNPD.

Age structure and growth of round whitefish was examined in 1980 and 1981. For 1981, age and length data from September and October were added to the spawning study data previously reported. The only other age and growth data from BNPD consisted of a small sample obtained during BNPD (Bruce GS 'A') pre-operational studies in 1974-75 (OHRD Report 78-52-K). These data are summarized and compared to growth data from other Great Lakes locations in Table 3.2-17. Ages of whitefish examined at Bruce GS 'B'/BNPD ranged from 0+ to 8+, with the majority 3+/4 to 6+/7. The 1974, 1975 and 1977 year classes all appeared to be strong, while the 1976 year class was relatively weak. At BNPD most round whitefish were mature at age 3+, at approximately 330 mm fork length, and maximum size was approximately 430 mm. Growth was similar to that reported for Lake Michigan, slightly lower than Lake Ontario and considerably greater than in Lake Superior (Table 3.2-17).

Longnose Sucker *(Catostomus catostomus)*:

This species contributed to 10% of the May-November catch in all gear types, second only to alewife. Suckers are considered coarse fish, largely unexploited by the sport fishery and of low commercial value (Ont. Min. Nat. Res. Publ. 1981). They also quickly grow beyond a size at which they serve as forage for piscivorous sport fish. Nevertheless, their numbers suggest a substantial influence in the nearshore ecology.

Gill net catches indicated that longnose sucker, present near shore in low numbers during the winter months (December to February), moved inshore in late March-early April. Peak abundance occurred in May (1979) or June (1980, 1981), and catches from July to November were quite variable. Gill net catches and acoustic census suggested that most longnose sucker moved offshore to depths of 12 to 30 m in summer and fall. Longnose sucker appeared to be considerably more abundant in the southern portion of the study area although previous studies indicated that this species was abundant north of BNPD, at Scott Point and Sand Bay (OHRD Report 84-47-K).

The extent of spawning, if any, by this species in the Bruce GS 'B' study area would appear to be minimal. Age 0 longnose suckers were rare in larval tows and beach seines. Spawning is reported to occur in streams and lake shallows (Scott and Crossman 1973), and has been observed in Underwood Creek, which flows into Baie du Doré (OHRD Report 80-45-K).

TABLE 3.2-17

GROWTH OF ROUND WHITEFISH
AT BNPD AND OTHER GREAT LAKES
LOCATIONS: MEAN FORK LENGTH AT AGE

	Study									
	BNPD						FORK LENGTH			
	1974-1975[1]		1980[2]		1981[3]					
Age	n*	FL+	n	FL	n	FL	Pickering 1982[4]	Darlington 1976-1977[2]	L. Mich. 1964[2]	L. Sup. 1963[2]
0+/1			1	160						
1+/2			1	200						
2+/3	8	340	5	277	1	200	300		265	180
3+/4	10	341	24	320	47	327	343	380	325	233
4+/5	5	364	12	360	66	349	369	390	350	272
5+/6	2	336	34	398	19	366	411	415	398	298
6+/7	1	345	54	403	40	402	417	440	418	320
7+/8			20	415	20	414			430	330
8+/9			1	398	7	428				355

* n = sample size
\+ FL = Fork Length

Sources: 1, OHRD Report 78-52-K, Appendix 2
2, OHRD Report 82-205-K, Figure 3.3.4-2
3, OHRD Report 83-451-K, Appendix 16 (September to December)
4, OHRD Report 82-460-K, Figure 3.6-3

OHRD data were lengths for age + fish in fall.

Feeding and growth of longnose sucker at Bruce GS 'B' were examined in 1979. A variety of benthic taxa occurred in the stomachs, with dipteran larvae being the most common. Cladoceran zooplankton occurred in a number of stomachs, but probably contributed insignificantly to the diet by weight. The majority of fish aged were between 7 and 14 years of age (Figure 3.2-6), with the older fish attaining a fork length of approximately 400 mm. Growth, as determined by length-age curves, was intermediate in comparison with published values from western Canada (Rawson and Elsey 1950, Reed 1962).

White Sucker *(Catostomus commersoni)*:

This was the second most commonly taken sucker species, contributing 7% to the overall May-November catch. White sucker often occurred together with longnose sucker, although some differences in seasonal and spatial trends in distribution were apparent. Gill net catches of white sucker were lowest in winter (December to February; Figure 3.2-3) and were much lower than those of longnose sucker during spring (late March to June). In the year of greatest abundance (1980) catch-per-unit-effort peaked in summer (July and August), while in 1979 and 1981 it peaked in fall (September and October). As with longnose sucker, the majority of white sucker taken in spring were caught in shallow (3 m) nets, while the majority taken in summer and fall were taken in deep (12 m) nets. However a larger proportion of white sucker than longnose sucker were taken in shallow nets, particularly in summer. In all three years trap net catches (sampling 2 to 3-m depth) of white sucker in summer were higher than those of longnose sucker. Such differences in distribution between the two major sucker species are in keeping with published information suggesting that white suckers tolerate warmer water than longnose sucker (Hart 1947, Scott and Crossman 1973). Although white sucker, like longnose sucker, were more common in the southern portion of the Bruce GS 'B' study area, at BNPD they were more commonly observed and caught in heated water (Bruce GS 'A' discharge and Baie du Dore) than were longnose sucker (OHRD Reports 80-45-K and 84-47-K).

Spawning of white sucker has been observed in Underwood Creek to the north (OHRD Report 80-45-K), and may also occur inshore in the lake. Few age 0 fish were taken in larval tows or beach seines, although they were not quite as rare as age 0 longnose sucker. At present it appears unlikely that the Bruce GS 'B' study area is utilized extensively as a spawning or nursery area by either sucker species.

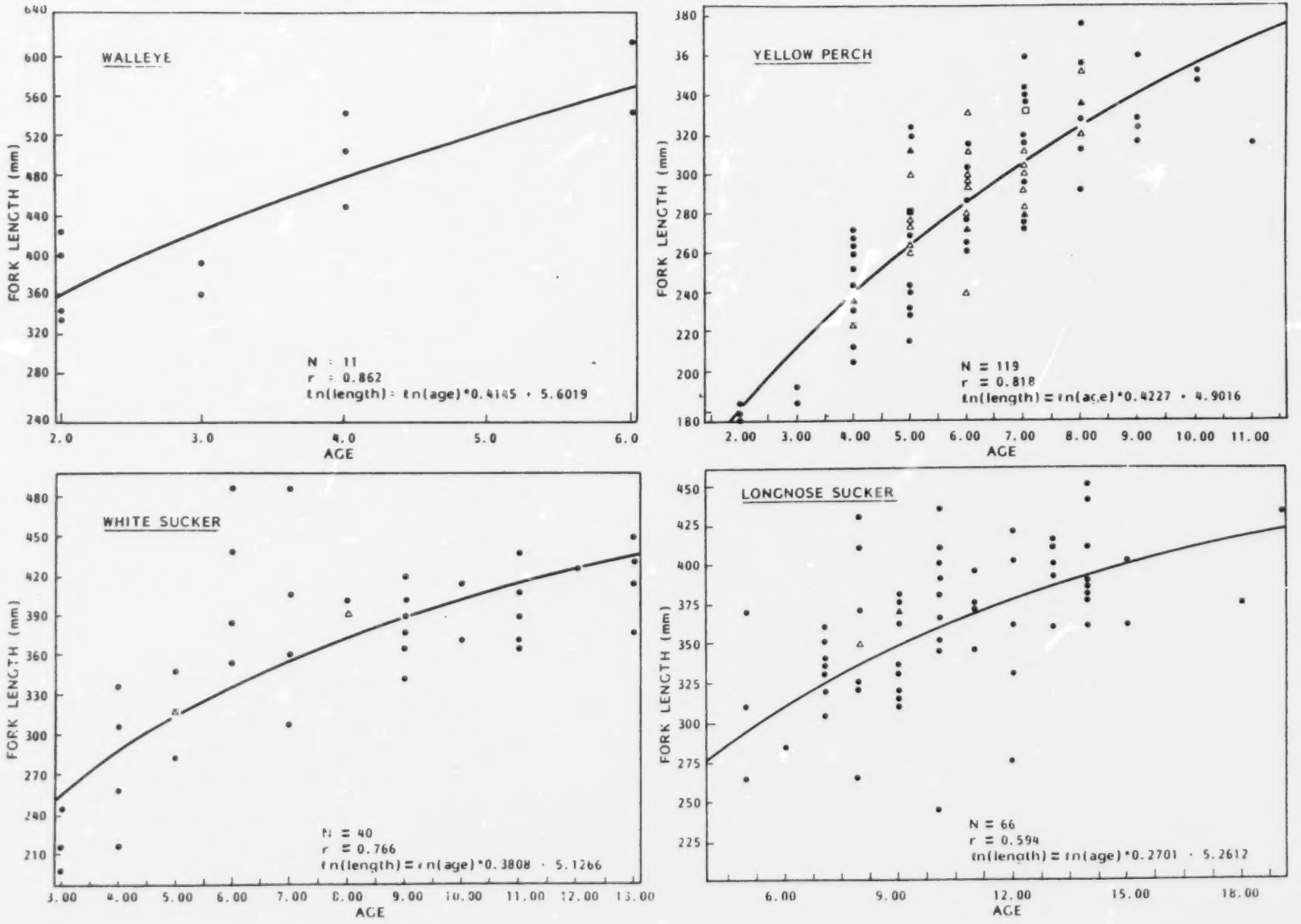

FIGURE 3.2-6

AGE-LENGTH RELATIONSHIPS OF FISH CAPTURED IN THE VICINITY OF BRUCE GS 'B' FROM MAY - NOVEMBER 1979

Feeding and growth of white sucker were investigated in 1979. The diet of white sucker was similar to that of longnose sucker, consisting primarily of a variety of benthic invertebrates, with dipteran larvae being the most common. A larger proportion of white sucker than longnose sucker took amphipods, which may suggest that this species was more likely to forage in areas of sediment accumulation or heavy periphyton growth. Fish eggs were also included in the diet. Growth of white sucker was somewhat more rapid than that of longnose sucker, with 9 year old fish reaching a fork length of approximately 400 mm (Figure 3.2-6). Growth of white sucker at Bruce GS 'B' was slower than in the majority of examples cited from the literature (OHRD Report 83-182-K). Slower growth may be due to a cooler temperature regime or competition with congeneric species (longnose sucker) for a limited food resource.

Yellow Perch *(Perca flavescens)*:

In 1980 May-November netting, yellow perch ranked third, contributing 11.7% of the catch in all gear types. However, catches were much lower in 1979 and 1981, and perch contributed 7% to the catch over the three years. Catches of yellow perch were considerably higher than at BNPD. Although in recent years the value of commercial landings of yellow perch in Ontario has exceeded that of any other species by almost an order of magnitude, they are less important in Lake Huron, where they rank a distant second behind landings of lake whitefish (Ont. Min. Nat. Res. Publ. 1981). The major area for commercial fishing of yellow perch is in the southern portion of Lake Huron, with landings in District 3 which includes BNPD, being relatively low. Although yellow perch are valued by anglers, there does not appear to be a significant sport fishery for them in the vicinity of the site.

Gill net catches of adult and juvenile yellow perch in the Bruce GS 'B' study area were insignificant from December to May (Figure 3.2-3). Perch first appeared in the area in significant numbers in June, after their spawning period, and occurred to varying extents from June to October. In 1980, the year of highest abundance, catches remained above 10 fish/set from June to October. Discrete peaks in catch occurred in August, 1979 and October, 1980. Overall, yellow perch were caught in approximately equal numbers in inshore (3 m) and offshore (12 m) nets, and no consistent seasonal trend in depth distribution was apparent. Perch abundance appeared to increase from north to south, with largest catches obtained at McRae Pt.

The rarity of adult yellow perch in the study area during and prior to the spawning period (late April and May; Scott and Crossman 1973) and the low numbers of larvae collected (43 over

the four study years) indicated that spawning of yellow perch in the area was limited. Spawning habitat for yellow perch is largely confined to areas containing submerged aquatic vegetation (OHRD Report 76-335-K, Scott and Crossman 1973). Substantial numbers of age 0 yellow perch appeared at southern locations in summer of 1980, but, since the larvae of this species have a pelagic phase (Faber 1967), their origin may have been remote. Somewhat lower catches at Sand Bay in the same year represented the only significant catches of larval or postlarval yellow perch at the BNPD site north of Douglas Pt. In the Lennox region of the Bay of Quinte yellow perch spawned in several locations and larvae were sampled in abundance. Following the pelagic larval stage, however, age 0 fish were difficult to capture (OHRD Report 76-335-K). It is therefore possible that southern portions of the Bruce GS 'B' study area serve as a nursery area for age 0 yellow perch in summer and early fall.

Feeding and age and growth of this species were examined in 1979. Yellow perch at Bruce GS 'B' were found to be feeding largely on fish. The diet of perch at BNPD (Bruce GS 'A') appeared to be more varied, with crayfish assuming considerable importance. During the period July to August, 1974, SCUBA divers observed that crayfish, although common between Scott Pt and Gunn Pt, were present in great densities in the extensive offshore boulder fields between McPherson Bay and Scott Pt. (casual observations). Most perch examined in 1979 were age 4 to 8 (year classes 1971 to 1975). There was little evidence of exceptionally strong or weak year classes within that range, although this may have been an artifact of sample selection. If 1980 was an exceptional year class for yellow perch, as suggested by netting of age 0 fish, then catches of perch may be high over the 1984-1987 period. A fork length of approximately 300 mm was attained by age 7, and growth appeared to be faster than at other locations in the Great Lakes or elsewhere (Figure 3.2-6; OHRD Report 83-182-K). Perch collected at BNPD in 1974-75 showed growth similar to that observed in 1979; this was faster from age 4 on than in fish from Pickering, Darlington or Lennox Generating Station sites on Lake Ontario and the Bay of Quinte (OHRD Report 78-52-K). The Lennox population was considered to be stunted due to high density, but it is unclear whether density dependent or other factors account for the difference between Bruce and the northwestern shore of Lake Ontario.

Gizzard Shad *(Dorosoma cepedianum)*:

This large clupeid species contributed only 2.6% of the May-November catch, but accounted for 41% of December-April catches. Gizzard shad are coarse fish of negligible commercial

value, and their rapid growth soon makes them inaccessible as forage for sport fish. They are of particular concern to Ontario Hydro because of their potential for massive influx to cooling water intake systems and resulting operational problems (e.g. at Bruce GS 'A', OHRD Report C78-31-K). At generating stations gizzard shad typically appear in the heated discharge channels in large numbers in late fall, and are observed there until late winter (e.g. Bruce GS 'A', OHRD Report 81-308-K; Lake Ontario stations, OHRD Report 83-372-K). At the Bruce GS 'B' site, nearshore abundance, as indicated by gill net catches, was low from May to September, then increased abruptly to peak in October (1979, 1980) or November (1981). Gizzard shad then virtually disappeared during early-mid winter (December-February), only to re-emerge and dominate the gill net catch at the end of March. Cold intolerance apparently prompts movement of gizzard shad to warm tributaries, including thermal discharges in late fall (Bodola 1966; Cox and Coutant 1976). Peak catches obtained in late fall and early spring may have represented fish migrating to and from heated discharges at BNPD where they likely remain resident during the coldest part of winter. In all three years fall catches of shad were highest on the Bruce GS 'B' discharge and intake transects, and lowest at the southern sites, furthest removed from the heated discharges of Douglas Pt, BHWP and Bruce GS 'A'. In March/April, 1981 catches were highest on the Bruce GS 'B' discharge, intake and Gunn Pt transects.

Absence of gizzard shad larvae in all years and very low abundance of adults in spring indicate that spawning was not occurring in the Bruce GS 'B' study area. The possibility of gizzard shad spawning in Baie du Doré has been suggested, and this is supported by the continuing occurrence of adults in spring and summer and catches of shad larvae at that location. Low catches of age 0 gizzard shad in beach seines suggest that embayments at the site are not utilized as a nursery area, possibly due to the lack of macrophyte growth and the exposed nature of the shoreline.

Spottail Shiner *(Notropis hudsonius)*:

This benthy-pelagic cyprinid was second to alewife in May-November netting. However, 75% of the spottail shiners were taken in a single year (1980) and most of these were age 0 fish caught in beach seines in late August at two locations (Gunn Pt and Holmes Bay). Although fish larvae identified as spottail shiners were rare, a substantial number of unidentified cyprinids, which may have been spottail shiner, were taken in 1981. Due to its numbers in the nearshore area, this may be an important forage fish for valuable piscivorous species, such as yellow perch, which also frequent inshore waters in summer.

Adult spottail shiner made up a large proportion of spring beach seine catches, and it is assumed that they were spawning along the shoreline at this time. Adults apparently moved offshore in summer and fall, as the majority of spottail caught in gill nets at this time were taken in 12 m nets. The young apparently remained close to shore during their early life history, but largely disappeared from shallow waters by October.

Lake Chub *(Couesius plumbeus)*:

This relatively large minnow was among the most common species taken in 2.5 cm (1") gill nets, contributing 6% to the overall May-November catch. However, comparisons of catches in larger meshes (3.8-12.7 cm) and trap nets, which were fished in all three years, suggest that numbers of lake chub in the area may be declining. This was consistent with year-to-year changes in the Bruce GS 'A' study area (OHRD Report 84-47-K).

Peak gill net catches of lake chub were obtained in May (1979, 1980) or June (1981). At this time the majority of chub were taken in shallow (3 m) sets and moderate numbers were also caught closer to shore in trap nets and in beach seines. Few lake chub were taken in summer, but numbers increased slightly again in fall, when the majority of fish were caught offshore. The apparent negative association between lake temperature and lake chub density may explain the decreasing trend in abundance of this species over years, coincident with an increase in the extent of thermal enrichment at BNPD. This species was taken during the winter months as well, but in relatively low numbers. Moderate gill net catches of lake chub were made throughout the study area, although catches were generally higher on the Bruce GS 'B' discharge, Holmes Bay and Gunn Pt transects. Trap net catches in spring, which are assumed to consist of large, mature chub, were highest at Holmes Bay in 1980 and 1981, and at Gunn Pt in 1979.

Although the presence of large chub inshore in May suggests the possibility that spawning may have been occurring in the study area, age 0 lake chub were not identified from larval tows or beach seines. Thus it appears that the Bruce GS 'B' area may be of limited importance as a spawning or nursery area for this species. Adult lake chub are potentially important as a forage species for piscivorous fish in the Bruce GS 'B' area.

Burbot *(Lota lota)*:

This large, demersal fish dominated mid-winter (January-February) gill netting, and was among the most common species in

larval tows, contributing 8% to the total catches over three years. The burbot is considered a coarse fish, with negligible commercial or sport value. However, unlike other coarse fish, it is a piscivore and has been implicated as both a competitor and predator of more valued species (Scott and Crossman 1973).

Burbot were caught in gill nets at the site throughout the year, but numbers were generally low from June to September. Largest catches were obtained in February, when burbot appeared to be closest to shore. At this time the majority of fish were found in the northern half of the study area. Burbot may occupy deeper waters in the vicinity of the station in moderate numbers through the warmer months, as is suggested by their importance in Bruce GS 'B' dumpsite catches at the 33 to 35-m depth (OHRD Report 87-174-K).

The timing of peak inshore occurrence of adults suggested that burbot may have spawned in or near the study area in February and March. Burbot larvae first appeared in mid-May and peaked in late May or June. Most larvae caught were recently emerged, and the developing larvae probably dispersed rapidly to deeper strata.

Walleye *(Stizostedion vitreum):*

This large piscivore is a valued sport and commercial species taken in the vicinity of Bruce GS 'B'. In addition to being highly prized by anglers, walleye and yellow perch were ranked behind lake whitefish in value of commercial landings reported from Lake Huron during 1976-80 (Ont. Min. Nat. Res. Publ. 1981). The total number of walleye taken in May-November netting was 170, with catches in 1980 and 1981 being considerably higher than those in 1979. Similar numbers of walleye were taken at BNPD (Bruce GS 'A'), where catches also increased substantially over the three years (OHRD Report 84-47-K).

Walleye were rare from December to July. They first appeared in gill nets in August (1980) or September (1979 and 1981), and peaked in abundance in October. They were taken in both shallow (3 m) and deep (12 m) sets along the entire shoreline, with no obvious trend in distribution. At BNPD the largest numbers of fish were caught within the Bruce GS 'A' discharge; there they occurred over a longer period (July to mid-January) than in the Bruce GS 'B' study area, although the time of peak abundance (fall) was similar.

Walleye were absent from larval tows and beach seines, and no adults were caught during the normal spawning period (April-May; Scott and Crossman 1973), so that it can be assumed that

Bruce GS 'B' is not utilized as a spawning or nursery area by this species.

Feeding, age and growth were examined in 1979. Stomach contents consisted entirely of fish, with smelt and alewife the only species identified. The fish aged ranged from age 2 to 6, with the largest number (4) age 2 (1977 year class). Although no walleye were aged or measured in other years, casual observations indicated that the majority were adults. A tagged adult walleye collected in October, 1981 was part of a spawning run in the Thames River, Lake St Clair in March, 1980. It can be suggested that walleye occurring at Bruce GS 'B' are widely ranging fish, and factors operating to affect year class strength at remote locations will probably have the most important influence on year-to-year abundance at the site.

Smallmouth Bass *(Micropterus dolomieu):*

This valued sport fish was relatively unimportant at Bruce GS 'B', in comparison to its status in the BNPD (Bruce GS 'A') study area, where it has been the object of extensive studies (University of Toronto Inst. Environmental Studies Report, 1983). A total of 81 smallmouth bass were taken at Bruce GS 'B' (all months) compared with 266 at BNPD during the same period. The largest numbers of bass were taken at Holmes Bay and Douglas Pt, in the summer and fall, well after the spawning period. In future, shoreline modifications and the addition of the Bruce GS 'B' plume may result in increased utilization of the area by smallmouth bass.

3.2.6 Nesting Gulls

The armour stone and landfill areas of the Bruce GS 'B' construction site were surveyed, coincident with a larid survey at the Bruce GS 'A' site in 1980. No nesting was observed at Bruce GS 'B', although a colony of approximately 6000 nests, primarily of ring-billed gulls, was observed at Bruce GS 'A'. The lack of colonization of the Bruce GS 'B' site may have been due to construction activity observed during the survey.

4.0 SUMMARY

4.1 Physical and Chemical Characteristics

Substrate and Sedimentation

The Bruce GS 'B' site has a relatively steep gradient, and is exposed to wave action generated by prevailing winds. Bottom substrates are dominated by exposed bedrock and boulder-cobble. Pebble-gravel substrates were found principally in the region of

Holmes Bay and Gunn Pt, while fine substrates (sand and silt) were largely limited to Holmes and Inverhuron Bays, and varied considerably in extent from year to year.

The rates at which inorganic and organic material accumulated in sediment traps generally decreased with increased depth and were greatest on the Holmes Bay transect. Organic content of sediments was lowest in the southern offshore portion of the study area, and appeared to increase towards shore and to the north. Sedimentation rates were highest in fall, presumably due to the action of storms in removal and resuspension of fine materials from shorelines and shallow depths. Highest rates occurred in 1980, followed by 1979 and 1981. The influence of construction activity was not readily apparent in spatial or temporal sedimentation trends.

Temperature, Oxygen and Transparency

Seasonal nearshore temperature trends from April to December were examined with reference to continuous data collected at 2-m depth near the Bruce GS 'B' discharge location. Temperatures increased from 4°C in late April to a maximum of 22°C in August, declining again to 4-6°C by early December. Extreme short-term temperature fluctuations (amplitude up to 16°C), attributed to wind-induced upwellings of cold offshore waters, occurred from June to September, during the period when thermal stratification was established at depths of less than 30 m. Fluctuations were less frequent and smaller in the latter part of the year, when the nearshore area was essentially isothermal. Due to frequent mixing of the nearshore area, oxygen content of the water remained at or above saturation values.

Water transparency was relatively high, ranging from 2 to 8 m, and generally increased from shore outwards.

Water and Sediment Chemistry

Water chemistry analysis included 31 parameters, though only eight were examined in all three years. Where comparisons were possible, values were in agreement with other Lake Huron data, and reflected the oligotrophic and unpolluted status of those waters. Values for several parameters, primarily those indicating nutrient status, were often below limits of detection, making interpretation of temporal or spatial variation difficult. Some seasonal and year-to-year differences were apparent, but these were generally not strong and consistent. With the exception of high slica values in bottom samples, and lower turbidity in offshore samples, no spatial trends were apparent.

Common elements sampled in Bruce GS 'B' sediments in 1979 included calcium, aluminum, iron and potassium. Values were obtained for a total of 40 metals, only two of which (cadmium and lead) were below the limit of detection in some samples.

4.2 Biological Characteristics

Plankton

Phytoplankton and zooplankton were investigated from grid samples obtained in June, August and October, 1979. Phytoplankton biomass was an order of magnitude higher in June (1 145 mg/m^3) than in August or October, reflecting the spring bloom of diatoms. Diatoms were also dominant in August, but were replaced by blue-green algae in October.

Seasonally dominant rotiferan zooplankton were *Synchaeta* (June), *Conochilus* (August) and *Keratella* (October). The crustacean zooplankton was dominated by copepod nauplii; *Cyclops bicuspidatus thomasi* was next most abundant in all months. Rotifers were most abundant in June (9 732/m^3) and crustaceans in August (13 680/m^3). No spatial trends in community composition or abundance of phytoplankton or zooplankton were identified.

Attached Algae and Zoobenthos

Similar numbers of attached and epiphytic algal taxa were collected in 1979 (19), and 1981 (20). The attached algae *Ulothrix* was common in both years, but *Chaetonema* and *Bulbochaete* were present only in 1979 and 1981, respectively. *Ulothrix* persisted into the summer at warmer temperatures than has previously been reported. Highest algal biomass (83 g/m^2; ash-free dry weight) appeared to occur in Lagoon Bay shoreline samples in June, but contamination by detrital material hampered comparisons. The reported biomass values were quite low in comparison to those observed in Lake Erie.

The zoobenthos was dominated by oligochaetes and dipterans, which together accounted for 97% of the organisms collected in both 1979 and 1981. At the specific level, an apparent shift in dominance from *Nais paradalis* in 1979 to *Nais simplex* in 1981 may have reflected taxonomic difficulties; dominance of *N. simplex* has been reported for similar Georgian Bay environments.

Zoobenthic community composition varied seasonally and spatially. *Nais* -dominated assemblages (from Mutual Information Analysis, 1981 data) were widespread at shallow depths in June-July, with dipteran-dominated assemblages prevalent offshore.

In November dominance of diptera had extended to several of the shallow locations, particularly in the southern portion of the study area. Zoobenthic diversity did not vary appreciably with depth, but was highest on the Holmes Bay transect, which also had a relatively high proportion of small and fine substrates.

Mean zoobenthic density was slightly higher in 1981 than in 1979; this difference probably reflected timing of sampling relative to storms (wave distrubance) and seasonal life cycles, rather than real changes in zoobenthic abundance. With the exception of decreasing zoobenthic density with depth, no other consistent temporal or spatial trends were apparent.

Fish

The May-November catch of adult and juvenile fish in gill nets, trap nets and beach seines totalled approximately 50 000 over the years 1979, 1980 and 1981. The combined catch was dominated by alewife (42%) spottail shiner (16%) and longnose sucker (10%). Other species contributing 2% or more to the catch were white sucker, yellow perch, lake chub, rainbow smelt and gizzard shad. Round whitefish was the only moderately abundant salmonid species, while the most numerous game fish were walleye and smallmouth bass (total catches of 170 and 81 respectively). Gizzard shad dominated winter gill netting, although they tended to be most abundant in March-April. Ichthyoplankton tow net sampling conducted in spring and early summer produced 16 species, with rainbow smelt (71%), alewife (15%) and burbot (8%) dominant. Taxonomic composition of the fish community was generally similar to that observed in the BNPD (Bruce GS 'A') study area during the same years. Principal differences could be attributed to the more exposed nature of the Bruce GS 'B' site. Rainbow smelt, round whitefish and longnose dace were relatively more abundant at Bruce GS 'B', while rock bass, brown bullhead and bluntnose minnows were less abundant.

Significant among-year differences were found in the gill net catch of six of seven major fish species. Yellow perch, longnose suckers and white suckers were caught in larger numbers in 1980, while gizzard shad and lake chub were more abundant in 1979. Round whitefish appeared to be increasing in numbers, with significantly higher catches in 1981. Catches of alewife, the most abundant species, remained relatively constant. Seasonal peak catches approximated the reproductive period in the case of alewife, longnose sucker, spottail shiner, lake chub (spring), round whitefish (fall) and burbot (late winter). In contrast, other important spring-spawning species appeared in largest numbers in summer (yellow perch) or fall (white sucker, gizzard shad, rainbow smelt and walleye).

The only significant alongshore trend in gill net catches of major fish species was the occurrence of larger catches of yellow perch and white suckers along the southern transects. Most of the more abundant species were well distributed along the entire study area. Inshore-offshore differences (comparing 3 and 12-m gill nets) were more pronounced. The majority of species were caught in larger numbers inshore, although seasonal inshore-offshore movements were apparent for several of these.

Adult and juvenile fish distribution and abundance was also determined acoustically through the water column from the 5 to 35-m depth contours. Overall, there did not appear to be appreciable year-to-year changes in fish abundance in the nearshore area. Estimated fish density at 11-15 m depth on transects nearest the Bruce GS 'B' intake location, which may indicate potential entrapment, ranged from 232 to 1253 fish/ha. Fish were usually most common near the bottom, and distributed across isotherms intersecting the bottom; only in some late-summer samples did their distribution appear to be related to thermal gradients.

The distribution and abundance of age 0 fish was inferred from larval tow net and beach seine catches. Seasonal peak densities of rainbow smelt were substantially higher in 1981 than in other years, while highest densities of burbot larvae occurred in 1982. Most larvae of the major species were recently emerged, and this was reflected in the seasonal peaks in tow net catches. Smelt appeared to move offshore rapidly and this was substantiated by the restriction of larger larvae to bottom tow samples. In contrast, developing alewife larvae were caught in moderate numbers in inshore surface tows, and post larvae later appeared in beach seines. Post-larval spottail shiner and yellow perch also appeared in beach seine catches occasionally in large numbers. Holmes and Inverhuron Bays may be significant as nursery areas for age 0 fishes of several species. Wind-induced mass water movements such as alongshore currents and upwellings appeared to influence the distribution of larval fish.

The relation to man, ecology and biology of twelve major fish species at the site were described. Most of the more abundant species at the site can be considered either as forage fish (alewife, rainbow smelt, spottail shiner and lake chub) or as coarse fish (longnose and white sucker, gizzard shad and burbot) which do not contribute to the sport or commercial fisheries. These species, by virtue of their numbers can be assumed to have an important influence on the nearshore trophic structure. Suckers, rainbow smelt and burbot are also potentially important predators on the eggs, larvae and juveniles, respectively, of more valued species. The two abundant pelagic clupeids, alewife

and gizzard shad, have the potential to create operational problems through massive impingement.

Round whitefish and yellow perch are potentially valuable as commercial or sport species, although they do not currently appear to be important in the fisheries of northeastern Lake Huron. A total of 900 round whitefish were captured during pre-operational studies, the majority being mature adults taken in fall. The temporal distribution of ripe and post-spawn fish indicated that spawning of round whitefish was occurring in the vicinity of the site from late November to early December at water temperatures of 5 to 7°C. No discrete spawning locations could be identified, however. Most fish taken in fall were age 3+ to 6+, and the 1976 year class appeared to be relatively weak.

Yellow perch young and adults utilized the nearshore area in the vicinity of Bruce GS 'B' in numbers which were highly variable from year to year. Yellow perch did not appear to spawn within the study area. Growth rates of yellow perch collected at the BNPD site (1974 and 1979) were greater than those from other Great Lakes locations.

Two valued sport fish, walleye and smallmouth bass, were taken at the site in relatively small numbers, although walleye abundance may be increasing. Neither species appears to be utilizing the Bruce GS 'B' site as a spawning or nursery area.

Nesting Gulls

No nesting activity was found at the Bruce GS 'B' site in 1980, although at the same time a large colony was present on the Bruce GS 'A' site (OHRD Report 82-182-K). Casual observations in the springs of 1981 and 1982 confirmed the absence of nesting gulls during the remainder of the pre-operational period. The

south side of the Bruce GS 'B' discharge provided suitable habitat for nesting and was considered a potential site for colonization once construction was completed.

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